ORAL SURGERY

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BY

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AND 16 COLOR PLATES

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TO

MY SON

STERLING GARRETT MEAD

PREFACE TO THE THIRD EDITION

This treatise upon oral surgery was primarily written for students of dentistry. An endeavor has been made to present all of the subjects in sequence and in a plan best adapted to teaching purposes. It has been my aim to present the practical application of oral surgery from cases within my own experience and to give the proper references to the experience of others

Students of dentistry have the common fault of being usually interested in the spectacular and not always so much interested in the commonplace everyday occurrences that should mean so much to them. There is no harm in being interested in the spectacular and difficult operations of oral surgery, but one should be more interested in the practical phases.

The call for another edition of this book has afforded the opportunity to condense as much as possible the description of the various operative procedures and forms of treatment which have been successful in my hands, to bring the book up to date, presenting the knowledge obtained since the first edition, and to make certain corrections in the text

Often men with little experience or limited experience are too eager to attempt new procedures and give written accounts of them, when such procedures are frequently more spectacular than practical As an illustration, there has been a widespread interest in external fixation by the use of metal plates and screw attachments for fractures of the jaws There are, of course, some advantages to this type of appliance when used by experienced operators, and there are cases in which such appliances can be used to advantage, but in the majority of cases the simpler methods are the better As one improves in operative technic, his methods and the description of methods become more simplified. New and valuable improvements are coming out of the war effort to benefit oral surgery, many of these have been added to this book.

There exists considerable confusion in the literature with reference to nomenclature relating to the scope of oral surgery. The terms exodontia, oral surgery, maxillofacial surgery, and plastic surgery are often used without definite limitation. Two definitions will clarify the situation · all surgical operations of the mouth and adjacent structures, including removal of teeth, more properly belong to oral surgery, the major type of surgery of the face, neck, and mouth, especially of the reconstructive type, belongs to plastic surgery.

I wish to thank my associates, Dr Daniel F. Lynch, Dr Charles L Smith, Dr. Marcus H. Burton, and Dr. Sterling G Mead, for their assistance and encouragement

STERLING V. MEAD.

PREFACE TO THE SECOND EDITION

'here have been a number of reprints of *Oral Surgery* since it was t published in 1934 The publication at this time of the Second ition has enabled the author to bring the work up to date There been an ever increasing interest in oral surgery, and both the stu-it and the practitioner have become more cognizant of the necessity knowledge and improvement in this branch of dentistry

Many valuable additions to the literature have been recorded, and have attempted to cite the outstanding advances Modern methods investigation have developed many advances in surgical procedure is has been especially so in infections of the face, neck and floor of e mouth, periodontal disease, cleft palate and cleft lip, surgical preparation of the mouth for dentures, fractures, improvement in medica-on, etc This edition has also given opportunity to present many iprovements and additions to the entire text

The publisher has generously permitted the addition of considerable ew material as well as many new illustrations

The recommendations of the Committee on Nomenclature and the ouncil on Dental Therapeutics of the American Dental Association ave been followed very closely

I am indebted to my associates, Doctors Howard J Newton, Daniel Lynch, and Reed O Dingman for their splendid cooperation In ddition to those mentioned in the first preface, I am under obligation o Doctors Wilbur McL Davis, Thomas Cajigas, Matthew N. Federspiel, lin Kirkland, and Mr Cary Sage

S V M

Washington, D C

PREFACE TO THE FIRST EDITION

Oral surgery may be defined as surgery of the mouth, mandible, maxilla, and adjacent structures

It has been my endeavor to present in this book the practical side of oral surgery It is hoped that the book will serve as an aid to the dental practitioner in dealing with problems of oral surgery and to students as a textbook

There appears to be a need for a book on oral surgery containing subject matter especially selected and arranged for instruction of the undergraduate dental student, yet sufficiently concise and systematized as to permit of accommodation to the limited time of the college curriculum

Special emphasis has been given in this work to the importance of a thorough knowledge of anatomic relationships, choice of anesthetic methods and sterilization In addition to the subjects usually found in books on oral surgery, chapters on "Hospitalization," "Preoperative Preparation," "Physiotherapy," "Postoperative Treatment," and "Diet and Nutrition," have been added. An effort has been made to standardize the nomenclature, using the terminology recommended by the Committee on Nomenclature of the American Dental Association A chapter on "Special Drugs for Surgery of the Mouth" has been added in an endeavor to present only drugs and remedies acceptable to the Council on Dental Therapeutics of the American Dental Association

During the past few years there has been a marked advance in diagnosis and surgery and many valuable books have been added to our literature. In most of these books the more serious surgical conditions are quite fully discussed and the so-called minor oral surgery is condensed into a few chapters, not fully illuminating or sufficiently extensive to meet the needs of the dental student The importance of minor oral surgery is not always sufficiently recognized in our dental schools; in many cases an attempt is made to teach major studies to those who would do well to grasp the minor ones Also this field of minor oral surgery is the only one into which the average dental practitioner will enter

Every dentist should become qualified in recognizing a pathologic condition in the mouth, but the practitioner should attempt treatment of only those cases which he is fully qualified to manage successfully and carry to completion, even though complicated by extension to other parts

While all oral surgery is of major importance and while it is improper in one sense of the word to speak of minor oral surgery, I see an advantage from the teaching standpoint of dividing oral surgery into minor oral surgery and major oral surgery.

This book is confined to the surgical aspect and no attempt has been made to cover the field of diagnosis, diagnostic methods, infection, and stomatitis A thorough schooling in many of these subjects more properly belongs to a course in diagnosis, and my book *Diseases of the Mouth* was written with the idea of presenting the subject of diagnosis to the dental student preliminary to the course in oral surgery Surgery necessitates a thorough knowledge of diagnosis, since without the ability to recognize the various diseases of the mouth and without the necessary experience in their treatment, intelligent surgery is not possible

It is very difficult to attempt to limit the boundaries of the field of oral surgery There is a very close relationship between diseases of the mouth and adjacent fields and general systemic disturbance.

The dentist should be able to recognize pathologic changes in the mouth and adjacent structures, but he is not called upon to perform surgical operations unless he has had special training in this field It is equally important when a patient is referred for surgical treatment that the one who refers the patient should have an intelligent idea of the most appropriate method of treatment.

In procedures involving oral surgery, opportunity is afforded for co-operation among the dentist, general surgeon, physician, and those whose practices have been limited to rhinology, ophthalmology, otology, pediatrics, dermatology, pathology, bacteriology, and other divisions of medical practice

While the various procedures for surgical treatment of the maxillary sinuses are discussed in this book, it is well known that the rhinologist is better fitted for this special work, as well as for diseases extending into the throat, and that the best results are obtained by the proper co-operation between the rhinologist and the oral surgeon

It is equally apparent that surgical operations, such as removal of the gasserian ganglion, are best performed by those surgeons skilled in brain surgery

It is also true that operations of extensive resection of the jaw, operations upon the tongue, dissections of cervical glands as well as other operations involving extensive plastic surgery can be best performed by those whose experiences, training, and practice have especially fitted them for this work

This book is the result of experiences gained during eighteen years of active practice in this particular field aided by a large consulting practice, many hospital connections, and twelve years of teaching Reference has also been made to the best that has been written in books, magazines, and journals by others working in this field

Because of the advantage of graphic description, a vast number of photographs, roentgenograms, and drawings have been used

The chapter on "Cleft Lip and Cleft Palate" has been prepared by Dr Chalmers Lyons, of Ann Arbor, Mich, whose work in this field is well known to the dental profession The author is also obligated to Dr Lyons for many valuable suggestions

Dr Olin Kirkland, of Montgomery, Ala, and Dr Harry M McFarland, of Kansas City, Mo, have contributed the material for the chapter on the "Surgical Treatment of Periodontal Disease" Dr Kirkland has very ably presented the technic of the more conservative flap operation Dr. McFarland has described his modification of the Ward operation

Dr Samuel M Gordon, of the Council on Dental Therapeutics, of the American Dental Association, has contributed many valuable suggestions for the chapter on drug therapy

The author is also under obligation for suggestions and assistanc to the following: Dr. N. P. Barnes, Prof George A Bennett, Dr R Bodine, Dr. Bryant Carroll, Dr C. N Chipman, Dr. William I Duncan Dr. B. E. Erikson, Mrs. Kathleen Fishback, Dr. Boyd S Gardner, Dr John W. Harper, Dr. Carl Henning, Dr E C Hume, Dr. C Leibe Dr. L W. Johnson, Dr Joseph P. Madigan, Dr. Cecile Markowitz, J Lavinia Mankin, Dr. Wm. Gerry Morgan, Mr R J. Reedy, Dr Clyde W. Scogin, Dr. Roy L Sexton, Dr. John J. Shugrue, Dr Geo F Seeman, Dr. A. Malcolm Smith, Jr, Dr. Edward L. Thompson, Dr J E. Tolbertson, Dr. George Winter, Dr. E R Whitmore, Mr A. G Wiswell, and Dr Wallace M Yater He is also indebted to Garne W. Jex for his splendid efforts in preparing the drawings

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CONTENTS

skin of the patient and personnel, (b) in the noses and throats of the patient and personnel, (c) in the air of the operating room, and (d) on the instruments, dressing material, etc.

Skin of Patient and Personnel

The inability to completely sterilize the skin of the operative site and the hands of the personnel constitutes the weakest link in the chain of aseptic technic, and these areas are probably the most prolific sources of wound infection The skin, owing to its anatomic structure, is incapable of sterilization in a bacteriologic sense The difficulty lies not in the epidermis, which is readily accessible for cleansing, but rather in the sweat and sebaceous glands and the hair follicles of the intradermal region in which numerous organisms are constantly present, even in the case of fastidious individuals These estuaries are so constructed as to form an anatomic barrier against both mechanical and chemical approach Consequently, sterilization can at best be only relative, irrespective of the mode of preparation The skin through which the knife must necessarily pass is an unavoidable source of wound contamination, inasmuch as the instrument, in its downward course, is bound to force some bacteria into the wound But, as has been said before, detailed attention to skin preparation will reduce the number of microorganisms to such a point that the bactericidal properties of the tissues may successfully cope with this minute infection

The method employed in the preparation of the skin of the operative site and the hands of the surgical personnel consists of mechanical cleansing with lipolytic agents, chemical sterilization with bactericidal agents, or a combination of both Mechanical cleansing with a fat-dissolving agent removes the grease and detritus present on the skin surface as well as the organisms that reside in the epidermis This method meets with universal approval, since it is a well-known fact that mechanical cleansing does not interfere with the vitality of the tissues and therefore permits them to exert their inherent bactericidal properties Indeed, in some clinics such cleansing is deemed entirely sufficient The value of supplementary preparation of the skin with antiseptics is subject to great difference of opinion Some surgeons advocate the use of antiseptics as a further safeguard, while others believe that they are not only unnecessary but actually harmful, in that they lower the resistance of the tissues to bacterial invasion

Price (77) has recently introduced a new method of measuring the germicidal action of the various agents used in skin disinfection A large number of basins of sterile water were prepared and the hands and forearms scrubbed with soap and brush in a standard manner for exactly one minute in each basin, one after another The total number of bacteria found in the basins was plotted against the time of scrubbing and this formed a regular, logarithmic curve By employing two such series of basins and plotting the curves independently, the germicidal effect of any disinfectant used in the interval may be studied quantitatively The table (page 5) prepared by Price illustrates the application of the test

Price found that scrubbing with brush, soap, and warm water reduced the basic flora by approximately ½ with each 6 minutes of scrubbing The kind of soap, the temperature of the water and its character, whether sterile or tap, made no difference, but the amount of vigor used in brushing was an important factor He found the

optimum germicidal strength of ethyl alcohol to be 70 per cent by weight rather than by volume as ordinarily prepared. The bacteriologic effect of washing the hands and arms in 70 per cent (by weight) alcohol for 1 minute is represented graphically in figure 1

Theoretically, the ideal skin antiseptic should (1) rapidly kill bacteria, (2) be capable of penetrating the surface, (3) dry quickly to prevent delay in the operation, (4) be non-toxic, (5) cause no interference with healing, (6) be stable, and (7) be inexpensive. Despite the number of agents recommended to fulfil these requirements, laboratory and clinical results of their use have not sustained the contentions of their enthusiastic advocates. It would seem that so long as the skin is mechanically cleansed with

[1] *Results of an Experiment Done to Determine the Effect of Washing in 78.5 Per Cent (by Weight) Alcohol on the Bacterial Flora of Hands and Arms*

BASIN	SCRUBBING TIME	TOTAL BACTERIAL COUNT FOR BASIN ORGANISMS	CUMULATIVE TOTALS WASHED OFF ORGANISMS	ACTUAL TOTALS OR SIZE OF FLORA LEFT, ORGANISMS
	minutes			
				2 822 370 (a)
1	1	1 497 440	2,272 370	1,324,930
2	1	166 320	774,930	1 158 610
3	1	197 960	608,610	960 650
4	1	132,770	410 650	827 880
5	1	66 300	277 880	761 580
6	1	74 000	211,580	687,580
7	1	74 680	137 580	612 720
8	1	62 720	62,720	550 000 (b)
At this point hands and arms dried in the air and then washed without friction in 78.5 per cent (by weight) alcohol for exactly sixty seconds. Scrubbing resumed immediately Temperature of alcohol 25° C.				
				318,595 (c)
9	1	30 070	178 595	288 525
10	1	31 840	148 525	256 685
11	1	22 655	116 685	234,030
12	1	28 420	94,030	205 610
13	1	24 360	65,610	181 250
14	1	17 730	41 250	163 520
15	1	23,520	23 520	140 000 (d)

(a) Total number of bacteria on the hands and arms at the beginning of the experiment, (b) after eight minutes of scrubbing· (c) after application of the germicide (d) after the second period of scrubbing· b and d are arrived at by mathematical projection of the curves produced.'

lipolytic agents, the particular antiseptic chosen makes little difference, provided it is non-irritating

Preparation of Operative Field. The advisability of aseptic preparation of the field of operation on the night before is subject to a difference of opinion Some surgeons (77) believe that such preparation is bacteriologically useless and psychologically harmful and merely prescribe a full bath at this time Others, however employ a routine preparation such as the following The bed is covered with a rubb sheet to prevent soaking during the scrubbing process. With a sharp razor all v as well as invisible hair over an area extending well beyond the limits of the prop incision is removed, care being taken to avoid abrasion of the skin The shaved is then scrubbed gently but thoroughly with green soap and hot water for 5 or 6

with special attention to parts in and around body folds and crevices, such as the spaces between the fingers and toes and the submammary creases During the procedure the lather is rinsed off at frequent intervals with sterile water In order to prevent mechanical injury, cotton swabs are used rather than the more irritating gauze After the scrubbing the skin is dried with a piece of sterile gauze, swabbed with ether, and washed for two minutes with 70 per cent alcohol by weight rather than by volume Price (77) points out the difference between per cent by volume and per cent by weight "Per cent by weight solutions are exact and invariable Per cent by volume solutions, as ordinarily prepared, are inexact and undependable owing to three uncontrolled variables—temperature expansion, specific gravity and reaction concentration Thus 70 per cent alcohol by weight (always the same) is the equivalent of 76 8 per cent by volume if the latter is prepared at 15°C but is the equivalent of 80.5 per cent by

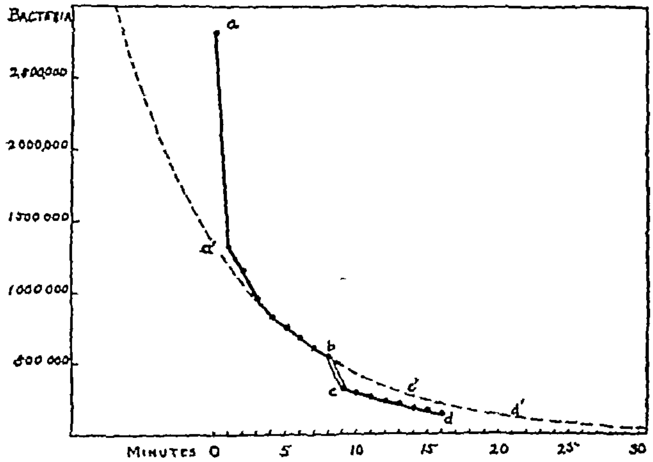


Fig 1 Chart, showing bacteriologic effect of washing hands and arms in 78 5 per cent (by weight) alcohol for one minute "The broken line *a′d′* represents the rate at which the basic flora of the author's hands and arms always are degermed by scrubbing in a standard manner The solid line *ab* indicates the effect of scrubbing eight minutes, while *cd* shows the result of scrubbing seven minutes in the second series of basins The initial deviation, *aa′*, from the broken line is due to contaminating (transient) bacteria purposely placed on the hands at the outset So, of the initial number of 2,822,000 organisms, only 1,350,000 were 'resident' This relatively small flora was due to the hands and arms having been well degermed two days previously and the usual flora not yet having been reëstablished The second deviation, *bc*, was due to use of the alcohol It is clear that, by scrubbing 4 2 minutes, *bc′*, the same effect (as *bc*) could have been obtained *cd* is equivalent to *c′d′* Hence each minute spent in this particular solution of alcohol may be said to be equivalent to 4 2 minutes of scrubbing" (Price, J A M A, 1938)

volume if the volumetric measurements are made at 25°C Accurate weight per cent solutions can be prepared from commercial (95 per cent) alcohol with the help of hydrometer, thermometer and appropriate tables The following formula will give a solution approximately 70 per cent by weight: 95 per cent alcohol at 25 C. 815 cc, plus cold distilled water sufficient to make 1,000 cc" Finally, the location of the operative field permitting, a light sterile dressing is laid over the part and secured in place by means of adhesive tape, to be left undisturbed until the patient is on the operating table A dressing of too great weight should be avoided, as it may cause perspiration and lead to maceration of the skin If the part to be operated on is covered with scabs or thickened epithelium, these should be loosened by the application of fomentations and should be removed prior to the scrubbing Suspicious lesions not formidable enough to contraindicate operation—such as acne—should be infiltrated

with phenol or acriflavin, neutralized with alcohol, and finally rinsed with sterile water

Immediately before operation the sterile dressing is removed and the operative site again prepared either by wet or dry sterilization.

(1) **Wet Preparation.** The parts are scrubbed gently for 10 minutes with green soap and warm sterile water The heat of the liquid expands the mouths of the glands, causing them to evacuate their contents, while the green soap saponifies the sebaceous material and removes the fatty protective covering of the bacteria. The green soap should not contain more than 4 per cent caustic potash, otherwise, it may act as an irritant to the skin and lower its resistance to infection. The saponified material and débris are removed at frequent intervals by copious douching with sterile water After the application of soap and water, the parts are swabbed with cotton sponges soaked in sulphuric ether to dissolve the remaining sebaceous material. Finally, a coat of 70 per cent alcohol is applied and allowed to dry out slowly in order to fix the surviving bacteria in the estuaries of the skin.

(2) **Dry Sterilization.** The wet method of preparation is messy and, unless due precautions are taken, the patient is obliged to lie in a pool of water throughout the operation, therefore some surgeons prefer dry sterilization

If *tincture of iodin* is to be used, the preliminary scrubbing with soap and water must be omitted, since moisture causes swelling of the prickle-cell layer and prevents the permeation of the antiseptic. If for any reason the skin is already moist, it must be artificially dried by swabbings with alcohol and ether before the application of the iodin It is essential that the tincture be fresh, as in old preparations the alcohol is partly evaporated, and the solution is stronger than it should be. The official strength is 7 per cent, but as iodin in this concentration usually proves too irritating to the skin, the tincture should either be reduced by one-half or applied full-strength and removed immediately after drying with 95 per cent alcohol. In the latter case special care must be taken to leave no trace of it, particularly in the natural body creases where it has a tendency to remain and burn the skin.

The operative site is draped with sterile towels and swabbed with benzene or ether to remove the grease. With a sponge held in a pair of long forceps, the iodin is next applied smoothly and evenly, beginning at the center and continuing toward the periphery The swab and forceps are discarded and the process repeated.

Fantus (22) states "Tincture of iodine is too irritating for this purpose [disinfection of the operative field] Mild tincture of iodine (2 per cent) should be used in its stead for skin disinfection. Research has shown that silk, a material which approaches the skin in chemical nature, absorbs much more iodine from aqueous iodine iodide solutions than from alcohol or glycerin solutions of equal iodine strength. This evidently because water, being the poorer solvent for iodine, gives it up to the ti… more readily than when the iodine is presented in a better solvent such as … or alcohol. Karns, Cretcher and Beal show that the amount of iodine deposited f… a 3 per cent aqueous iodine potassium iodide solution adhering to silk is ten times … great as from a solution of like strength in 70 per cent alcohol. In clinical trials solution of 2 per cent iodine strength has been found most satisfactory for the or… field. It is applied in excess, allowed to remain in place for from fifteen to … and then removed with absorbent gauze or cotton. The solution in diluted …

of 2 per cent each of iodine and potassium iodide is now the official Mild Tincture of Iodine."

As an alternative to iodin various other agents are employed for skin sterilization Some favor *picric acid*, as it does not burn the skin, is cheap, stable, and non-irritating On the other hand, it stains the skin and dressings, is inflammable, and may induce a dermatitis in patients sensitive to it It is employed as a 5 per cent solution in 95 per cent alcohol and applied in the same manner as iodin *Salts of heavy metals*, such as bichlorid and biniodid of mercury and organic compounds of mercury and silver, form a film on the surface which locks up the bacteria in the estuaries of the skin and renders conditions favorable for their multiplication. When these agents are used, therefore, the film should be removed with an alkaline sulfid (77)

The technic used at the Mayo Clinic is essentially as follows. (a) The skin is scrubbed for several minutes with gauze sponges and a hard alkaline soap containing powdered pumice. (b) The soap scrubbings are sponged off with sterile water (c) Harrington's solution is then applied and left on for 30 seconds, after which the part is swabbed with 70 per cent alcohol, and finally (d) tincture of iodin is applied

Mucous membranes are prepared for surgery by irrigation with large quantities of some mild antiseptic agent The conjunctiva is treated by frequent instillations of 2 per cent boric acid solution followed by 10 to 15 per cent argyrol For operations within the mouth the teeth and gums are scrubbed with a toothbrush and the mouth frequently washed with a fresh sodium perborate solution or half strength hydrogen peroxid

If surgery must be performed in the vicinity of septic sinuses, fistulae, ulcers, or granulating surfaces, attempts should be made to isolate them as far as possible from the field of operation. Sinuses and fistulae are plugged with sterile gauze, and granulating surfaces are sterilized with a cautery and walled off by means of sterile dressings and towels.

Operations on the various parts of the body require a special technic of preparation which will be described in the appropriate sections.

Hand Sterilization. Preparation of the hands is governed by the same aseptic principles as sterilization of the operative site The use of sterile rubber gloves would seem to make previous hand sterilization unnecessary, but in view of the fact that gloves may be accidently pricked at any time during the course of the operation, their use must not be allowed to provide an excuse for perfunctory hand cleansing For the same reason, the presence of an infected lesion, no matter how superficial, on the hand of any member of the operating staff, should automatically exclude that individual from participation in the operative procedure

The prerequisites for hand preparation are a plentiful supply of hot and cold running water operated by foot control, sterile wooden-backed scrub brushes with bristles not so stiff as to abrade the skin, nail files, curved manicure scissors, and green soap,—all kept in sterile containers at the side of the wash basin It is advisable to have a 10-minute hourglass at some place within easy view of the washstand While the essential details of scrubbing are more or less standardized, the relative merits of the various antiseptics to be used after the completion of the process and the choice between dry and wet glove technic is still a matter of dispute

(1) *Scrubbing* Before scrubbing, the surgeon and assistants change their street clothing for operating suits consisting of a soft shirt, white drill trousers, and a pair

of clean canvas or rubber shoes A cap and mask are donned and a rubber apron temporarily tied around the waist to prevent soaking during the scrubbing process

The consecutive steps of hand sterilization are as follows (a) The hands, forearms, and lower third of the arms are washed with soap and water for the removal of street dirt. (b) The finger nails are cleaned with an orangewood stick and cut short with scissors to prevent puncture of the gloves and to facilitate cleansing under the grooves All frayed skin and hangnails are clipped. The hourglass is turned and the actual scrubbing process is begun (c) The hands and forearms are held beneath a stream of hot water and deliberately scrubbed with green soap, the lather being frequently rinsed away At the end of 3 minutes the nails, now softened by the immersion and scrubbing, are again cleaned with the orangewood stick dipped in a little chlorid of lime and passed beneath them and along their lines of contact with the skin. The original brush and orangewood stick are then discarded. (d) With a fresh sterile brush and green soap and water the scrubbing of the hands and arms is continued for another 7 to 8 minutes. The process should be carried out systematically, beginning with the thumb, continuing to the fingers and then to the hand, forearm, elbow, and lower arm, the joints should be flexed and extended so that all surfaces are exposed. The scrubbing is interrupted from time to time by copious douchings with running water for the removal of the soap and débris. The vigor with which the superficial layers and crevices of the skin are scrubbed is more important than the length of time involved, but it should not be so forcible as to traumatize the skin. Throughout the process the hands should be held at a higher level than the elbows to prevent contamination of the hands from fluid trickling down from the arms.

Hand preparation up to this point is a generally accepted procedure but from here on one enters on debatable ground where a great variety of practices exist. Many surgeons advise that the scrubbing be followed by the immersion of the hands and forearms for 3 minutes in an arm-basin containing 70 per cent alcohol. Before immersion, the parts should be thoroughly dried with a sterile towel to prevent dilution of the alcohol by the water Others prefer to use bichlorid of mercury, biniodid of mercury, lime and soda iodin or a combination of these agents

At the Mayo Clinic the hands and forearms are scrubbed with pumice soap and running water and dried with a sterile towel, they are then immersed in Harrington's solution for 30 seconds, rinsed in alcohol, submerged in bichlorid of mercury 1 5 000, and finally sterile gloves are donned while the hands are in the solution

At Johns Hopkins Hospital the procedure advocated by Kelly (47) is employed After the usual scrubbing the hands and arms are immersed for 2 minutes in a hot saturated solution of potassium permanganate, after which the arms are placed in a warm solution of oxalic acid to remove the stains. The arms are then rinsed in sterile water and immersed in 1 5,000 bichlorid of mercury solution.

Some clinics use iodin for hand sterilization After the initial scrubbing the hands are immersed in a 3 5 per cent solution of iodin for 2 or 3 minutes and then placed in 70 per cent alcohol and scrubbed with a piece of gauze until the stain has disappeared.

(2) *Use of Rubber Gloves* As has been said before skin sterilization is at best only relative, and for this reason the hands must be covered with sterile rubber gloves The gloves may be put on by the wet or dry method but the latter is preferable, since it is practically impossible to prevent water from running down the arms over the gloves, thus endangering sterility A further objection to wet gloves is their tendency

to macerate the skin Whatever method is used, the gloves are not put on until the gown has been donned (fig 2) The hands are first dried with a sterile towel and dusted with sterile talcum With the fingers of the right hand covered with gauze the fold of the rolled-back cuff of the left glove is grasped and the glove drawn on, care being taken not to touch its *outer* surface (fig 3a-b) The sterile fingers of the left gloved hand are then inserted under the fold of the turned-back cuff of the right glove and this glove pulled on, equal care being taken not to touch its *inner* surface.

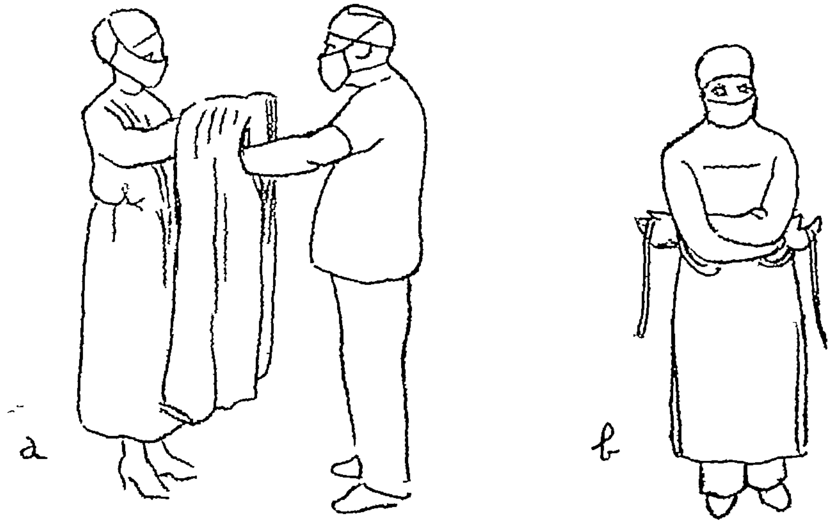


FIG 2 Method of donning operating gown *a*, gown held by nurse facing operator *b*, tapes held for nurse to tie, while arms are crossed to protect elbows

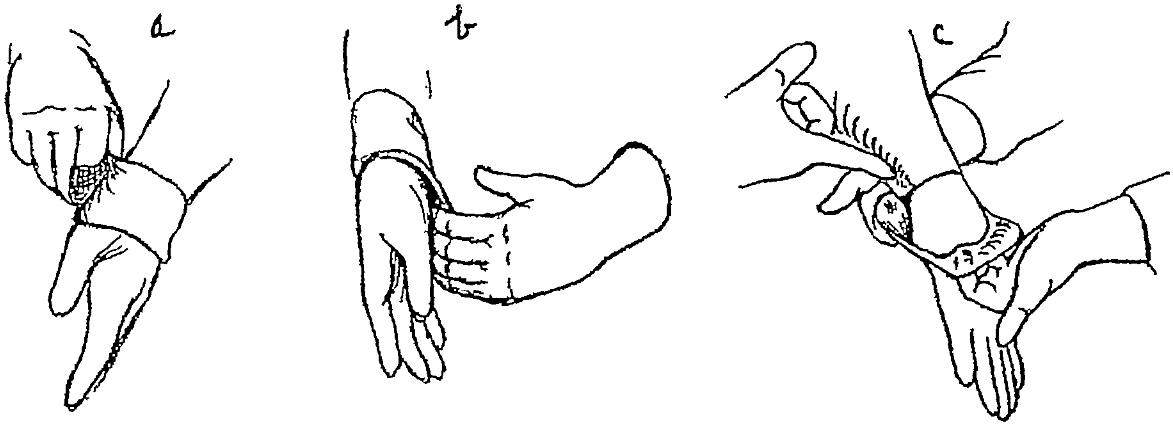


FIG 3 Methods of donning gloves. *a*, gauze-covered fingers of right hand grasp rolled-back cuff of left glove and draw glove on, care being taken not to touch *outer* surface *b*, fingers of left gloved hand inserted under turned-back cuff of right glove, and glove drawn on in similar manner, care being taken not to touch its *inner* surface *c*, glove held by sterile nurse, and hand thrust in without contact with outer surface of glove

The ends of the sleeves of the gown are now folded about the wrist and the cuffs of the gloves are folded back over them Finally, the gloves are adjusted over the finger tips with a piece of dry sterile gauze. Some operators prefer that the gloves be held by a sterile nurse, so that the hands may be thrust in without coming in contact with the outside of the glove (fig 3c) As a further precaution against contamination, the encased hands are held in front of the body above the waist line and wrapped in a sterile towel until the operation is begun.

Should the glove be inadvertently punctured during the course of the operation,

it is immediately discarded, otherwise, septic material may exude through the puncture hole and infect the wound. Not only should the glove be replaced by a fresh one, but the hand itself should be resterilized by immersion in alcohol for 1 minute for every hour that the glove has been worn, since a hand sterile at the beginning of an operation is soon contaminated by the bacteria coming to the surface with the perspiration from the follicles and sweat glands when the encased hand is overheated by the glove Price (77) has shown that bacteria multiply rapidly beneath rubber gloves, "their number doubling every forty minutes if the hands are dry or every fifty minutes if the gloves have been put on wet. If the gloves are worn long enough, the cutaneous flora may increase until it exceeds by far the ordinary flora."

Not only is it imperative to sterilize the hands immediately before operation, but it is equally essential that they be given special care between operations. They should be kept soft and pliable by frequent applications of a hand lotion, such as glycerin and rose water, since any roughness may favor the collection of organisms and increase the difficulty of sterilization Frequent visits to a manicurist will assist in keeping the hands free from hangnails. Septic material, such as soiled dressings or wounds, should never be touched with the bare hands, rubber gloves should always be worn and the dressings handled only with forceps. Kocher (50), in discussing the importance of rubber gloves in surgery, stated that "it was much more important to wear rubber gloves between than during the operation"

Air of Operating Room

Whereas formerly little consideration was given to the air of the operating room as a possible source of wound contamination, recently, with other factors largely under control, it is receiving more attention Meleney (69) has estimated that between 35 000 and 60 000 bacteria fall upon the operative field in the course of 1 hour, and similar observations have been made by Davis (16), Hart (37), and Gudin (30)

Dust Contamination. The danger from air contamination may be lessened by a reduction of the amount of floating dust in the operating room and by adequate protection of the wound and all sterile objects against dust. In the more modern hospitals the air entering the operating room is washed and filtered mechanically (p 25) All unnecessary accessories capable of catching dust, such as overhead fixtures, are done away with, and those which cannot be eliminated are wiped with a 50 per cent solution of glycerin and water to trap any dust particles that may settle. Walls and floors are frequently mopped with a germicide. Every motion which tends to disseminate dust, such as the opening and closing of doors and the general movements of the operating personnel, is reduced to a minimum During the operation all sterile objects not in immediate use are kept under sterile covers and canopies, and the wound is frequently irrigated with warm sterile normal salt solution In this connection it is interesting to note that Meleney found that agar plates exposed in a room where no operation was going on showed $\frac{1}{10}$ the number of bacterial colonies found on plates exposed in a room where there was the activity of an operation.

The amount of extraneous dust with its accompanying organisms can also be reduced if all the attendants are requested to change street shoes and clothing for operating apparel before entering the room, and if all unnecessary persons are excluded. Hart (36) states "Other things being equal, the number of bacteria in the air of a room in-

crease directly with the number of occupants and duration of the occupancy" Spectators are assigned to a gallery separated from the operating room by a plate glass partition and accessible through a private entrance By means of reflecting mirrors or a pair of opera glasses they can observe the steps of the procedure, and can hear through a microphone any explanations given by the surgeon In exceptional cases, when visitors are admitted to the room itself, they are obliged to adhere to the rules governing the operating personnel—i e , they wear caps, masks, and sterile gowns, and their street shoes are covered with cloth foot leggings or rubber boots They are requested to remain at a safe distance from the table and to preserve silence ' Enforcement of this rule is the responsibility of the operating room supervisor

Droplet Contamination. It is a well-established fact that the noses and mouths of the members of the operating personnel are prolific sources of wound infection (16) (69) Pathogenic bacteria, including streptococci, staphylococci, and pneumococci,

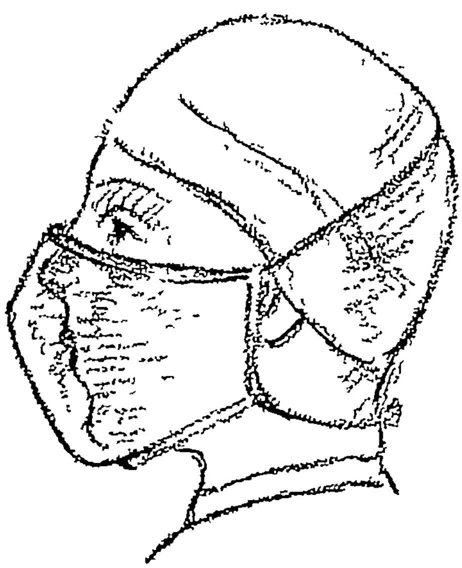


FIG 4 Transparent mask of plastocele (cellulose derivative) held in place by tapes tied around head Upper edge wedged in pliable aluminum band bent to fit shape of nose Lower edge shaped to catch perspiration drops (Waters)

are constantly present in the mouths of even healthy individuals, and these organisms, although harmless to their host, may develop deleterious propensities and incite infection when transferred to an open wound The bacteria gain entrance to the wound by way of droplets of saliva expelled during respiration or speech—particularly whispering, because of the sharper propulsion of the breath necessary in the formation of consonants Coughing and sneezing naturally increase the possibility of contamination It has been estimated that each droplet of saliva contains 66,250 organisms, half of which are pathogenic, and that these droplets travel for a distance averaging 30 cm , having a scattering range of 60 degrees in a sagittal direction and 80 degrees in a transverse direction (81)

(1) *General Prophylactic Measures* Unfortunately, no absolute protection against droplet contamination has as yet been evolved Therefore, whenever possible silence should be maintained throughout the operation and sign language resorted to (80) (76) (fig 5) To forestall the possibility of contamination by carriers, frequent cultures are made from the nose and throat of each member of the operating personnel.

Anyone suffering from a respiratory infection should be excluded from the operating room, as in such cases the bacteria are particularly virulent, and a relatively small number introduced into the wound may lead to serious consequences.

(2) *Masking* Masking of the noses and mouths of all persons in the operating room is the most important single measure in the prevention of droplet infection The imperative need of masking is emphasized by Meleney (68) who discovered that when he permitted the anesthetist to remain unmasked, the incidence of wound infection rose appreciably If a local anesthetic is employed, the patient likewise should wear a mask, lest he infect his own clean wound.

The essential requirements of the ideal mask have been well summarized by Walker "The ideal surgical mask should be one that (a) under all conditions will absolutely prevent the passage of organisms through the material of the mask in the direction of

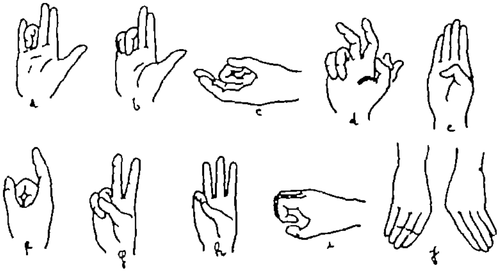


FIG 5 Sign language employed during operation. *a* artery clamp—ring finger flexed, and thumb abducted. *b* towel clip—ring and little fingers flexed, and thumb abducted. *c*, ligature—little and ring fingers flexed, and thumb touching ring finger *d* syringe—index and ring fingers extended, and to and fro motion of thumb *e* sponge—thumb abducted across palm. *f* scalpel—fingers flexed, thumb and index finger moved in cutting motion. *g* tissue forceps—index and middle fingers extended, thumb in contact with ring finger *h*, mouse-tooth forceps—thumb abducted and touching little finger *i*, retractor—fingers and thumb flexed. *j* towel—spreading motion with both hands (Pool and Bancroft)

the wound or material concerned with the operation when both the nose and mouth are covered, (b) will be comfortable in all degrees of temperature and will not fog the glasses, (c) will be of low original cost or of such construction that it can be used economically many times with sterilization following each use." Unfortunately, a mask such as the one outlined has not as yet been perfected (5) (104) (101) Walker, in an analysis of 60 different masks submitted by hospitals throughout the United States, found that none were capable of completely preventing the passage of organisms through the material. The one which has been found to offer the greatest protection is the helmet type which covers the hair, ears, nose, mouth, and chin, an opening being left only for the eyes.

The efficiency of the mask, according to Kellogg and McMillan (46), depends upon the number of layers and the fineness of the mesh. They believe that a 6-ply fine mesh gauze will prohibit passage of bacteria. Such a mask, however, renders breathing difficult. Blatt and Dale (5) increase the effectiveness of the ordinary mask by incor

porating in it a layer of an impervious material The one which they describe consists of a sheet of cellophane over which a double layer of gauze is sewn It is folded transversely across its center and held in place by means of the usual loops or tape at the sides of the face The upper and lower margins fit snugly against the face, while the center and sides are separated from it by the crease of the transverse fold This permits of the deflection of the exhaled currents of air outward and backward at the sides of the face Waters (104) employs "a mask made of a transparent, impermeable, light weight, non-combustible substance, a cellulose derivative called 'plastacele,' the upper edge of which is wedged in a pliable aluminum band in order that it might be bent to fit the

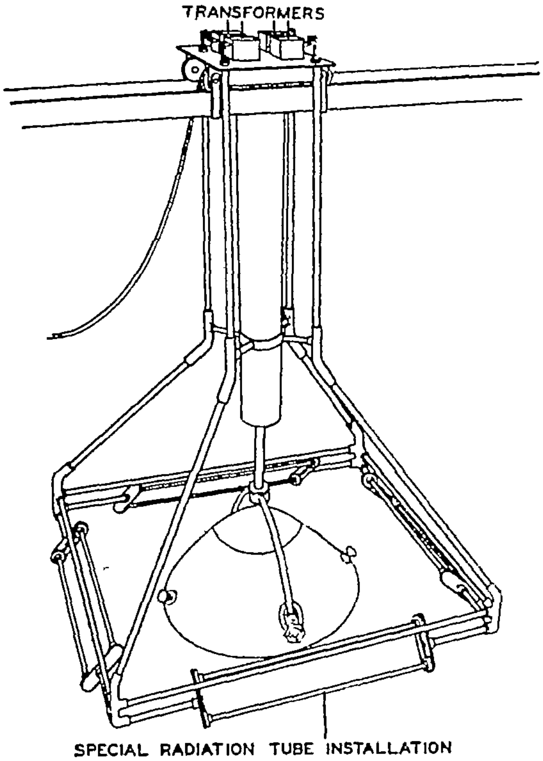


FIG 6 Sterilization of air in operating room by bactericidal irradiation Ultraviolet radiations in a range below 2600 angstroms, supplied by 8 tubes arranged in form of square, with tubes 5 feet apart Center of cluster is 4 feet above incision Supply and instrument tables are placed within range of radiation Air in entire room is not sterilized, but the barrage of radiation will kill organisms before they can settle in the wound Hart found that with this irradiation lightly sprayed cultures of staphylococcus aureus hemolyticus on blood agar plates were destroyed in 60 seconds, and heavily sprayed cultures in less than 5 minutes Practically all organisms exposed to the rays of the tubes at a distance of 8 feet were killed in less than 10 minutes, and at a distance of 10 feet in less than 30 seconds At 13 feet from center of cluster and 11 feet from the nearest tube, the number of viable organisms was reduced to from 60 to 90 per cent (Hart and Gardner, Tr So Surg Assoc , 1937)

shape of the wearer's nose It is held in place by ear pieces, or cotton tapes tied around the head, in the usual manner of tying masks [fig 4] That part coming under the chin is so shaped as to catch perspiration drops" Sabakow claims that absolute protection from droplet infection is impossible except by the use of a gas mask, but obviously such a mask could be endured for only short periods

Whatever type of mask is resorted to, its efficiency should be tested from time to time by the expedient of speaking through it into a prepared culture medium and, after incubation, examining the culture for evidence of contamination

Air Sterilization. In view of the fact that air-borne infection resulting from dust and

droplet contamination cannot be entirely eliminated, sterilization of the air itself has been suggested as a logical solution of the problem Continuous radiation of the air during operation is believed by Hart (36) to be the only means now available of disposing of pathogenic bacteria in the atmosphere of the room He uses a type of radiant energy in the ultraviolet spectrum supplied by a battery of 8 tubes so mounted that each tube is located approximately 5 feet from the incision (fig 6) The tubes have unheated electrodes and are filled with a mixture of gases in which the discharge takes place with a resultant production of radiant energy The tube itself remains at a temperature of only a few degrees above that of the room Hart has shown that this energy is capable, within 60 to 90 seconds, of destroying cultures of the hemolytic staphylococcus albus at a distance of 8 feet, and he has proved that during the operation there is a reduction of 95 per cent in the contamination

Good results following sterilization of the air by means of formaldehyd are claimed by Gudin. In order to insure concentration of the gas, the operating room is sealed, the formaldehyd is then blown into the room and subsequently neutralized with ammonia, the product being removed with a solution of tartaric acid As an additional precaution, the patient and personnel are compelled to pass through sterilized compartments before entering the operating room.

Instruments Fabrics, and Containers

Practically all *instruments*, with the exception of those with points and cutting edges, can be sterilized by boiling for 20 to 30 minutes in distilled water containing 1 to 2 per cent sodium carbonate (Tap water is best avoided since the chlorin used in its purification tends to cause corrosion.) The sodium carbonate removes greasy material, raises the boiling point, and prevents the tarnishing of steel. The instruments are placed in a removable perforated metal tray, lowered into the boiler, and the lid closed. They may also be placed on a towel in the bottom of the boiler In no event should they be allowed to come in contact with the bottom of the receptacle, as the direct heat of the flame will damage them. In order to obtain uniform heat throughout, it is important that the water be boiling before the instruments are immersed, that thev be completely covered, and that the lid of the sterilizer be closed. The first rule does not apply to instruments made of glass or of glass and metal, such as syringes, since the sudden expansion of the glass occasioned by the heat may cause it to crack. It is safer to immerse such instruments in the water while it is still warm and then gradually bring it to a boil After 20 to 30 minutes the tray containing the instruments is removed by means of sterile handles, in the absence of a removable tray they may be taken out one by one with a pair of boiled forceps. Another instrument sterilizer is that constructed on the principle of a steam cooker, and comprising a lower receptacle for water, and shelves above for the instruments, the whole being covered with a lid The steam caused by the boiling effects sterilization.

In many hospitals instruments are sterilized by steam pressure Walter (103) suggests a "specially designed and constructed steam jacketed autoclave of the conventional horizontal type (fig 7A) The accessory equipment, steam pressure regulator, operating valves air ejector and piping have sufficient steam capacity to complete the sterilizing cycle in a chamber 9 inches in diameter and 19 inches long in less than 4 minutes. Operation is simple, easy, and sufficiently quiet so that the sterilizer can

be used in the operating room without causing annoyance Steam is admitted to the jacket of the emergency sterilizer prior to an operation, and a steam pressure of 27 pounds (gauge pressure) is maintained until the operative procedure is finished Thus the sterilizer is instantly available and condensation in the chamber is eliminated . .

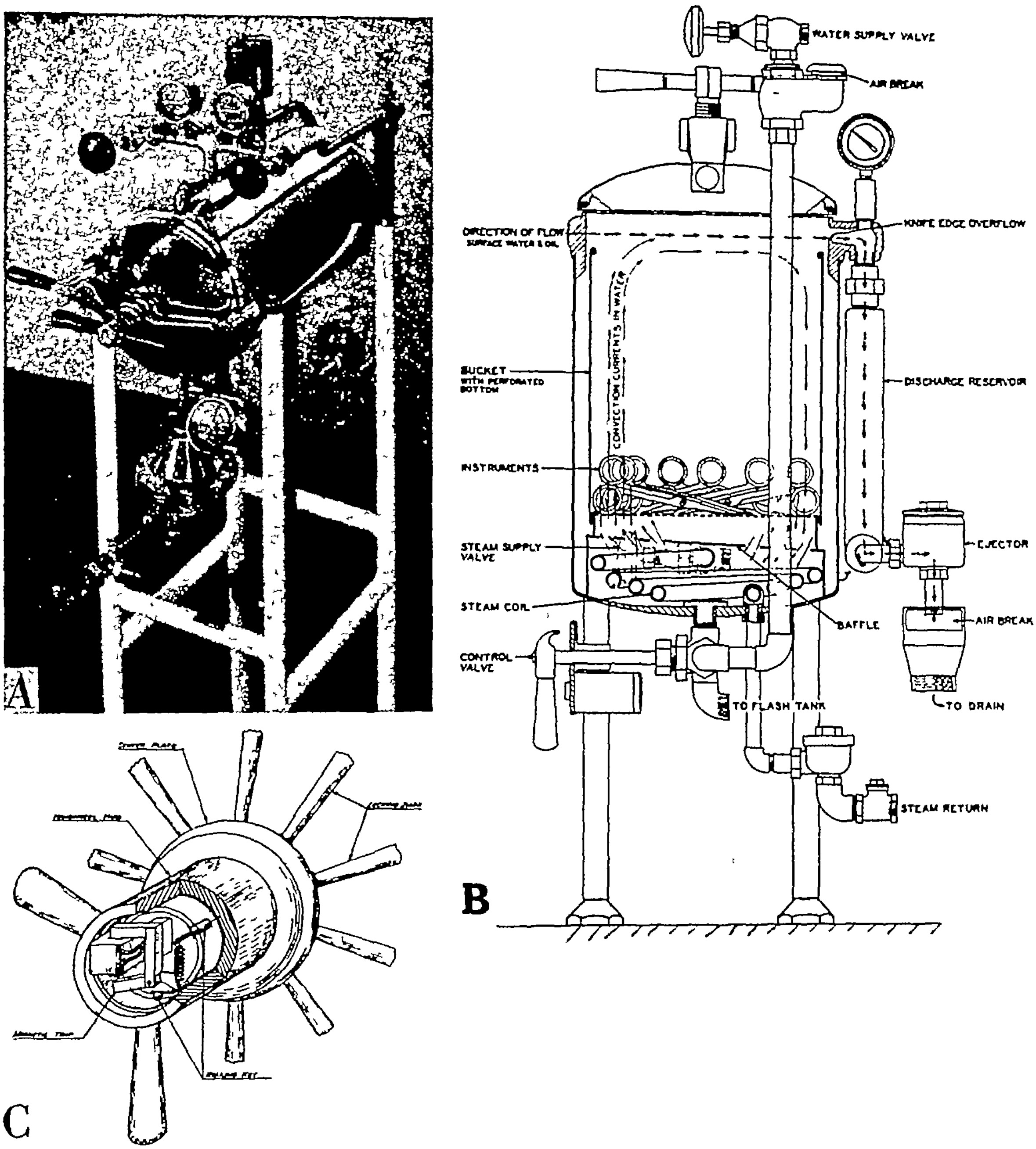


FIG 7 Walter's autoclave for rapid sterilization *A*, highspeed autoclave permits sterilization of instruments in 4 minutes *B*, diagram of sterilizer using superheated water as cleansing and sterilizing agent *C*, rolling key clutch mechanism which wedges hand wheel so that sterilizer cannot be opened until keys are released by magnetic trip at end of sterilizing cycle (Surg Gynec & Obst, 1938)

The clean, fat-free instruments are placed in the sterilizer on a perforated metal tray and the door is closed tightly Steam is then admitted to the chamber so rapidly that a sterilizing temperature of 273°F is attained in 40 seconds Spore of the most heat-resistant organisms can be destroyed at 273°F. in 2 minutes An automatic, recycling timer meters a consecutive sterilizing interval of 3 minutes and signals that the load is

sterile and that the steam may be vented. Pressure in the chamber can be relieved almost instantaneously A detachable handle is then fitted to the sterilizing tray and the instruments can be carried to the operative field without danger of dropping or contamination This technique enables the circulating nurse to return an instrument to the operating table with no compromise of aseptic technique less than 5 minutes after it was dropped to the floor "

For the cleansing and sterilization of instruments soiled by pus or feces or where spore contamination is likely, Walter advocates the use of "a vertical autoclave constructed to withstand an operating pressure of 27 pounds per square inch (gauge pressure) The dirty instruments are collected in a stainless steel bucket directly from the instrument table The bucket is placed in the sterilizer over a baffle which forces water to circulate through perforations in the bottom of the bucket (fig 7B) A steam coil, located beneath the baffle, supplies adequate heat for rapid sterilization and sets up convection currents in the water to carry the oil and grease, which leave the instruments and rise to the surface, toward an overflow at the rear of the sterilizer The continual rise in the water level, due to the expansion of the heating water, carries the oils and scum formed by the blood and pus over a knife edge overflow into a reservoir whence it is discharged into the drain by a special ejector The temperature of the water is raised to 273°F in 7 minutes, a signal light indicating when the steam supply is to be shut off The superheated water is rapidly drained into a flash tank, exposing the instruments to saturated steam for approximately 1 minute while the pressure is being relieved. The residual heat in the instruments is sufficient to flash any adherent moisture and the clean, dry, sterile instruments are ready for immediate use upon removal from the sterilizer"

Unfortunately, sharp or pointed instruments, such as needles, knives, chisels, and scissors, are blunted by prolonged boiling, and the above methods of sterilization must therefore be modified or the use of chemicals be substituted. The dulling effects of boiling will be somewhat minimized if the instruments are wrapped separately in gauze or placed in individual test tubes plugged with cotton, and the time of their immersion in the boiling water is limited to only 5 minutes instead of the usual 20 to 30 minutes. But even with such precautions some degree of dulling is inevitable. For this reason, chemical sterilization is frequently resorted to, despite the fact that it is *not so efficacious* as boiling Chemical sterilization is usually effected by the immersion of the instruments for half an hour in 70 per cent alcohol, pure phenol, or lysol. If phenol or lysol are chosen, the instruments should be neutralized in alcohol and washed with sterile water to prevent burning of the patient's skin. Numerous other antiseptics have been suggested for use in chemical sterilization. Meleney (69) advocates the Bard Parker germicide. Electrical instruments, such as lamps, electric cords, and light carriers, are wiped with 70 per cent alcohol, placed in specially constructed instrument cabinets, and sterilized for half an hour with formaldehyd gas admitted into the cabinet.

All cloth fabrics used in the operating room, such as wearing apparel, sponges, dressings, bandages, and drapes, and all other like objects which heat cannot destroy are usually sterilized in an autoclave by steam under pressure. This *method of heat* sterilization is superior to other forms in that the pressure causes the heat to permeate all parts of the material.

The autoclave is composed of two separate compartments—an inner chamber for the sterilization of the fabrics, and an outer jacket for the introduction of steam under

pressure—and is provided with a vacuum mechanism by means of which the air and moisture within the inner drum can be exhausted Autoclaves are constructed to operate at various degrees of steam pressure Ten pounds to the square inch corresponds to 115°C , 15 pounds to 121°C , and 20 pounds to 126°C. A pressure of 20 pounds to the square inch above atmosphere pressure for 20 to 30 minutes will kill all forms of bacterial life, including the most obdurate spores. The more elaborate sterilizers are equipped with an apparatus which records in graph form the duration and pressure of the steam within.

The articles to be sterilized are put up in packages and placed in metal drums in the reverse order in which they will be required Thus the article to be used first will be on top. They are packed loosely, in order that the steam may readily penetrate the materials. In the center of each drum is placed a control to check the efficiency of the sterilization. The loaded drums with their airholes open are then put into the autoclave Steam is admitted until the indicator registers 15 pounds pressure The vacuum valve is now opened to extract all the air and moisture. When the air has been exhausted, the vacuum valve is closed and steam is admitted until the indicator denotes a pressure of 20 pounds to the square inch, at which point it is maintained for 20 to 30 minutes The suction valves are then opened for the withdrawal of the steam, and the fabrics are dried either by the admission of sterile air or by the introduction of steam into the outer jacket. At the end of 15 minutes the drums are removed and their airholes closed.

Careful tests are made from time to time to determine the efficacy of the apparatus The most common controls used in these tests are the following. (1) A small glass tube containing a mixture of glucose and sulphuric acid is placed in the center of the drum When the temperature has been raised to the desired degree, the sugar will become caramelized, and the contents of the tube will turn brown or black (2) Fusible alloys that melt at the required temperature are placed between the dressings Unfortunately, these tests do not indicate the duration of the temperature, and for this reason they must be supplemented at frequent intervals by (3) bacteriologic tests A thread saturated with bacillus subtilis spores is inserted into the center of the material before it is put in the autoclave and after sterilization it is tested for evidences of bacterial destruction. Walter describes a new control for steam sterilization in use at present at the Peter Bent Brigham Hospital in Boston It insures sterility and eliminates every possibility of error through negligence on the part of the personnel "This control is fully automatic, indicates the various stages of the sterilizing cycle, and enforces a sequence of operation by impounding the load until the specified sterilizing cycle has been completed . . .

"The autoclave door is locked by a rolling key clutch mechanism mounted within the handwheel assembly (fig 7C). This clutch wedges the handwheel so that the locking bars cannot be retracted and simultaneously provides the takeup often necessary for sealing the door against leakage of steam as the chamber pressure builds up After the satisfactory completion of the sterilizing cycle, the rolling keys are released from their wedging position by a magnetic trip

"The sterilizing cycle is checked by a recycling, synchronous electric timer which is controlled by sensitive thermoswitches located in the exhaust line of the sterilizer.

"The sterilizer is operated according to the manufacturer's usual instructions When the locking bars are forced into position to secure the sterilizer door, a switch is actuated which energizes the control. A red signal indicates that the sterilizer is locked but that

the temperature is below that necessary for sterilization. After steam has been admitted to the chamber and the temperature of the steam reaches the sterilizing level, a thermoswitch, set for 250°F, starts the timer A combination of red and green signals now indicates that sterilizing conditions prevail. While the temperature of the steam remains above 250°F, the timer meters a consecutive interval until 30 minutes have elapsed when it trips a switch which changes the signal to green alone indicating that the load is sterile and that the steam may be shut off and the vent valve opened.

"After the pressure in the chamber has been relieved and the temperature falls to 210°F, a second thermoswitch closes, releasing the clutch. A white signal indicates that the load is sterile and that the hand wheel may be turned to retract the locking bars.

"If for any reason the temperature of the steam falls below 250°F, the timer automatically recycles and the entire 30-minute period must be repeated. Thus continuous exposure to saturated steam destructive to bacterial life is assured. "

To measure the penetration of steam into the bundles or drums, a steam-proof thermoswitch, set for 250°F., is placed in the center of the largest bundle or most tightly packed drum. "The timer then meters the duration of satisfactory sterilizing conditions in the center of the densest portion of the tightly packed load."

Rubber fabrics, such as rubber gloves, soft catheters, rubber tubing, rubber dam, and rubber bandages, are sterilized either by autoclaving for 15 minutes at 15 pounds pressure, or by boiling for 10 minutes in plain water The use of sodium carbonate should be avoided, since it deteriorates the rubber Moreover, these articles should not be boiled in the same container with the instruments, since rubber has a tendency to discolor metal. To protect the surface polish of gum elastic instruments they should be carefully lifted from the boiling water with a broad nosed forceps (107)

Gutta-percha and hard rubber articles, such as syringes, must be sterilized chemically, as boiling ruins them The usual method is to soak them in a 30 per cent solution of phenol or 1 1000 bichlorid of mercury for 2 hours. They may also be disinfected with formaldehyd in a fumigating cabinet.

Containers for solutions, instruments, and dressings should be free of cracks and crevices to permit of thorough cleansing and sterilization. These articles may be sterilized in the same manner as instruments by being boiled in water for 30 minutes or steamed in a box utensil sterilizer for an hour; or they may be autoclaved for half an hour If the latter method is to be used, they are first wrapped separately in muslin to prevent their chipping or cracking In an emergency, utensils can be sterilized if a small quantity of alcohol is poured into them and they are then set afire.

Maintenance of Normal Tissue Resistance

Insurance against infection is not entirely dependent upon the exclusion of bacteria from the wound. Equally important is the preservation of the bactericidal properties of the tissues themselves. Indeed, a wound treated with an imperfect asepsis but gently dealt with will be less liable to undergo infection than a wound of similar character treated with a perfect aseptic technic but subjected to undue operative trauma. As has been said before, even after the most rigid aseptic care a certain amount of bacterial contamination is inescapable. This minute contamination, however, does not interfere with wound healing, provided the bactericidal properties of the tissues are left

unimpaired When tissues are compromised by mechanical and chemical trauma, they are deprived of the capacity of exerting their germicidal powers and the few organisms which they would under normal circumstances destroy assume a greater importance and are enabled to set up infection

If the details of an atraumatic technic are strictly observed, the tissues will be left in the best possible condition to cope with the unavoidable contamination This implies protection against undue exposure, avoidance of mechanical injury in the handling of the tissues, notably rough manipulation, crushing with clamps, tight sutures, and prolonged retraction, limitation of the amount of foreign material in the wound, and avoidance of chemical and thermal damage from strong antiseptics or too hot applications

Undue exposure of the wound causes drying of the tissues, which in turn interferes with healing and predisposes to infection Therefore, the operation should be accomplished as expeditiously as is consistent with thoroughness and gentleness Speed without consequent tissue damage is best attained by adherence to a well thought out plan based on a thorough knowledge of surgical anatomy and surgical pathology, and by the execution of a step-by-step technic aimed at a preconceived goal Ochsner asserted that "an endless amount of trauma can be accomplished if a surgeon forms the habit of mauling the tissues while he is trying to collect his sluggish thoughts "

Rough manipulation of tissues sets up a traumatic inflammation which adds to the burden of repair by diverting the tissue energy, which should be directed toward destruction of bacteria, to the absorption and elimination of the inflammatory products The least amount of trauma will be inflicted if the tissues are incised with a sharp knife. A dull knife or blunt dissection causes unnecessary laceration of the tissues, and, by leaving irregular surfaces and dead spaces for the collection of fluid and bacteria, interferes with the blood supply and predisposes to infection Toothed forceps should not be used, since they crush the tissues, lower their resistance to contamination, and, when applied to the skin, they squeeze into the wound the bacteria lodged in the glands. While such organisms are innocuous in their normal habitat, they may set up an infection in the traumatized wound tissue During the course of the operation extravasated blood can best be removed by means of suction or by steady pressure with gauze for a few moments This inflicts less trauma than if the parts are mopped or rubbed with dry gauze sponges It has been aptly stated that "gauze has a tooth that can bite and tear and scratch " When ligation is necessary, care should be taken to grasp and ligate only the bleeding vessels, and for this purpose a sharp-pointed forceps is preferable to a blunt-nosed forceps, since the latter instrument has a tendency to incorporate too much tissue The ligature should be so placed that a minimal amount of tissue will remain beyond it Mass ligation is to be avoided, as it deprives the part of its circulation and leaves a large mass of devitalized tissue to be absorbed or to undergo infection It is essential that all significant blood vessels be ligated, since insufficient hemostasis leads to the formation of hematomata which will press unduly upon the tissues and interfere with the blood supply, delay healing, and predispose to infection Nevertheless, overzealous ligation is to be eschewed, as it unnecessarily traumatizes the wound and leaves an excess of foreign material to be absorbed

Avoidance of tension in the approximation of the wound margins is imperative in atraumatic technic, since excessive tension materially interferes with the circulation and thus predisposes to infection Subcutaneous sutures should not be tied so tightly as to

strangulate the tissues. One reason why Halsted (33) advocated the use of fine silk was the fact that such sutures would break before the tissues could be tied under too much tension Sutures should not be resorted to for the approximation of divided fat and muscle, since the delicacy of these structures renders them valueless, and the procedure inflicts unnecessary damage Skin sutures should do no more than lay the edges of the wound in apposition. The finest strand of suture material mounted on the smallest calibered needle compatible with safety should be employed.

The wound should not be exposed by means of forcible retraction of the wound margins A carefully planned incision, a proper arrangement of the illuminating apparatus, and a judicious recourse to traction sutures are ordinarily sufficient for adequate exposure, and there will be no necessity for forcible retraction, with its damaging effect upon the tissues. The indiscriminate use of drains in clean wounds should be avoided as they traumatize the tissues. When circumstances demand them, however, they should be removed as soon as they have subserved their function.

In all surgical wounds there necessarily remains a certain amount of foreign material in the form of sutures, débris, and damaged tissue Before tissue regeneration can take place, they must be either absorbed, encapsuled, or expelled. Meanwhile they act as culture media for the ever-present bacteria, delay healing, and promote infection. Therefore, the greatest care must be taken to limit such foreign material in the wound All non-viable tissue, such as hematomata or tags of bone, fat, muscle, or fascia, which have been separated from their nutritive bases, should be removed. The quantity of suture material can be minimized by means of careful ligation, fine ligatures, small knots, and cutting of the ends as short as is consistent with safety Metal plates and heavy sutures, such as kangaroo tendon, should be eschewed whenever possible. Recourse to chemical agents and extremely hot or cold applications to wound surfaces should be avoided, because of the trauma which they occasion

OPERATIVE EQUIPMENT

Surgical Block

Details as to the size, structure finishings, lighting, heating, ventilation, equipment, arrangement, etc., of the various rooms comprising the modern operating suite belong to the realm of architecture rather than surgery, and are beyond the scope of this book Nevertheless, there are certain features which are of particular interest to the surgeon and which require mention. The arrangement and equipment of the operating suite will have to be planned for each hospital individually, since every hospital presents its own problem, and no two cases are quite the same. Under all circumstances, however, the rooms must be so designed and equipped as to provide a maximum of safety for the patient and to afford the utmost convenience to the surgeon anesthetist, nurses, and attendants. As a rule, the simplest and most compact arrangement will be the most satisfactory from the standpoints of both efficiency and economy Every foot of unnecessary space increases the cost of construction and upkeep and means an unnecessary loss of time and waste of effort on the part of the operating personnel The location of the operating suite should be selected with a view to accessibility, so that the patient may be spared a protracted journey and its attendant complications consequent upon chilling and jolting On the other hand, it must be at such a distance from the wards as not to interfere with the comfort of pre- and postoperative patients.

Other factors to be considered in the selection of the site are light, absence of noise, and freedom from dust In a many-storied hospital these requirements are best fulfiled if the operating suite is located on the top floor and provided with special elevator service. In a pavilion-planned hospital the ideal situation is in a centrally placed building However, in view of the modern air-conditioning and lighting facilities, the question of location is not so important as formerly

The usual surgical block consists of (1) several operating units, (2) locker rooms for doctors and nurses, (3) x-ray and photographic room, (4) plaster room, (5) laboratory, (6) anesthetizing room, (7) recovery room, and (8) work room. It is practical to include in each operating unit two operating rooms serviced by a scrub-room and a sterilizing room. Whenever possible, separate units should be reserved for clean and unclean cases, but if the same room must serve for both, the clean operations are scheduled first (fig 8)

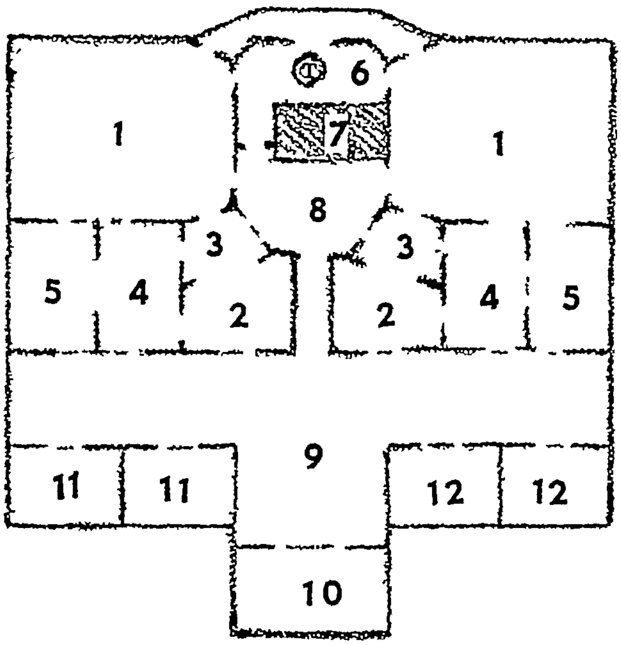


FIG 8 Plan of operative block suggested by Gosset. *1*, operating theater *2*, wash room *3*, dressing room *4*, anesthetizing room *5*, recovery room *6*, instrument room *T*, hopper for disposal of soiled materials *7*, sterilizing room *8*, work room *9*, service corridor *10*, passageway into operative block *11*, surgeon's room *12*, radiographic, bacteriologic, and pathologic laboratory

Operating Theatre

The ideal operating theatre is two stories high, with an arena averaging 10 meters square A larger space involves unnecessary expense for heating and cleaning, and a much smaller one entails unavoidable crowding, with its menace to asepsis. A gallery for spectators should form part of the operating theatre. It is placed at a distance of at least 8 meters from the center of the arena, raised above the level of the floor, walled off by means of a partition of plate glass, and provided with a private entrance. The floor of the operating theatre is made of a durable material that will withstand the effect of frequent flushings with disinfectants In order to minimize fatigue, it should be resilient, and as a precaution against accidental slipping on its surface when wet, it should not be too smooth For this purpose white tile, preferably composed of 5 cm blocks and free from cracks and joints, is most serviceable All corners should be

graded, and there should be a depressed central drain to permit of flushing with a hose. Metal inserts built into the floor will aid in dispersing any accumulated static potential generated by the anesthetic apparatus The Committee on Anesthesia Accidents of the American Medical Association advise "terrazo" floors with grounded brass strips. A system of electric signals to be operated by foot control, is often a great convenience The walls and ceiling should be smooth, free of ledges, cracks, and crevices to prevent dust accumulation, and should be made of a material which can be easily washed Some operating rooms are equipped with a wainscoting of gray tile extending 2 to 3 meters above the floor level While this material facilitates cleaning, it is expensive, turns yellow with age, and is liable to crack or drop off For all practical purposes plaster and paint serve the purpose equally well The color of the walls should preferably be some neutral tint, such as gray or buff with a lusterless finish Certain hospitals favor green because of its soothing effect on the eyes, but one objection to its use is that it makes it difficult to judge the patient's true color A sound proof wall is obviously of advantage, but unfortunately it is impractical because sound proofing, in order to be effective, requires that the walls be porous and free of paint, and these features interfere with cleaning Furthermore, sound proof construction is virtually impossible in a fireproof building However, a great deal of noise can be eliminated if the legs of all standing objects are provided with rubber cups, or if they are placed on rubber mats. A system of piping to provide oxygen and carbon dioxid and to furnish negative pressure for suction will obviate the cluttering up of the operating room with cumbersome paraphernalia and do away with the noise of an electric motor Radiator coils should be spaced sufficiently to permit of easy cleaning, and after they are washed, they should be covered with folded sheets Electrical connections should be installed between the operating room and the locker room and bulletin board All switches and plugs must be insulated and spark proof The walls may also be provided with a lighted recess for x-ray plates and a silent electric clock to be used in recording the progress of the operation. Doors should be smooth of surface to facilitate cleaning thick enough to exclude sound, and equipped with hinges that will permit of their swinging in and out and closing automatically They should also be furnished with a small window, as a precaution against collisions. It would seem that a door operated by means of a photo-electric cell would be a great convenience

Adequate *illumination* of the operating room is obviously essential, as insufficient lighting often necessitates prolonged pulling and retraction of the tissues to obtain visibility, and the resulting trauma impedes healing Every advantage should be taken to utilize daylight Glare will be avoided if the windows are so constructed as to throw a direct northern or so-called studio light Double windows are preferable, the outside being plate glass and the inside polished pyramid glass in the form of blocks joined together with weather stripping These blocks permit of an equal diffusion of light which will not dazzle the eyes Ordinarily skylights are to be avoided, as they collect moisture in cold weather intensify heat during the summer months, are difficult to keep clean, and admit a blinding light.

Artificial lighting can now be secured by the use of a great variety of fixtures The requisites of a satisfactory lamp are good illumination without glare absence of shadows, minimum of heat radiation, and ease of adjustment and cleaning The lighting may be either indirect or direct In the case of the former, the light is generated outside of the operating room and projected on a number of mirrors which reflect it into the

operative field Direct illumination is supplied by an overhead lamp suspended from a crane so that it can be swung out of the way when not in use, and placed high enough to avoid burning the operating personnel It is provided with a group of powerful electric globes capable of furnishing three different degrees of light and has a combined power of 600 watts The globes are made of frosted glass that will cast no shadows, and each one is furnished with a reflector so arranged that all the rays will focus on the operative site A glass plate is attached to the fixture below the globes to prevent dust from falling on the wound Other accessary lighting equipment comprises adjustable standing lamps or "spotlights" with powerful reflectors, and hand-lights on long rods similar to those used in bronchoscopy and cystoscopy for the illumination of deep wounds Whatever type of illumination is employed, it is important that an extra circuit be connected with storage batteries for use in case of a sudden failure of the regular current

The *heating* arrangements should permit of the maintenance of a temperature ranging between 75 and 80°F A temperature below 75° may cause the patient to become chilled when the blankets are removed for the preparation of the operative site, while one above 80° will induce excessive perspiration and lead to dehydration This temperature should be maintained not only in the operating room itself, but also in the corridors and elevators leading to it, in order that the patient may be protected against the consequences of a sudden change during transportation All entrances and exits to the operating room should be equipped with double doors to shield the patient from drafts during the operation The Committee on Anesthesia Accidents of the American Medical Association (110) recommends that the relative humidity of the operating room be maintained at 55 per cent This level is sufficiently high to guard against explosion from the accumulation of static electricity and to reduce the amount of fluid loss of the patient (113), and is low enough to prevent the formation of perspiration on the face, fogging of eyeglasses, and "sweating" of the walls and windows The most efficient method of heating, ventilating, and filtering the air of the operating room is by means of "air conditioning," a procedure whereby built-in shafts forcibly admit air previously washed, filtered, humidified, heated, or cooled, as desired Yaglou (113) states that the "main objectives in air conditioning operating rooms are to reduce the risk of explosion of certain anesthetic gases and to protect the patient and operating personnel against extremes of heat or cold in summer or winter Ether and ethylene in themselves are not explosive but they become explosive when mixed with air or oxygen in certain proportions

"Approximate Limits of Inflammability of Ethylene and of Ether

	LOWER LIMIT	UPPER LIMIT
	per cent	*per cent*
Ethylene in air	3 0	30±
Ethylene in oxygen	3 0	80±
Ether in air	1 7	6 to 50
Ether in oxygen	1 7	40±
Ether in nitrous oxide	3 8	26±

In the table are shown the limits of inflammability of these two common anesthetics

"It is evident from the table that the most critical period is during the 'washing out' process at the end of the operation, when the concentration is diluted to the explosion

range. The most serious cause of accidents is static sparks in dry atmospheres [40], a factor that cannot be entirely eliminated by grounding the anesthesia apparatus because it is difficult to make the rubber parts conductive to electricity By means of an electroscope, Herb [41] has shown that grounding affects but a small section of the rubber and that segments an inch or two away retain their charge. The same probability holds true for woolen blankets and clothing

"Air conditioning Equipment —Central station plants and individual room air conditioners have proved satisfactory in operating and postoperative rooms, furnishing between six and fifteen air changes per hour of filtered and suitably humified air, with provision for cooling and removal of excess moisture in warm summer weather The chief disadvantage of room conditioners is their noise Re-circulation of air is not used extensively in operating rooms partly because of odors and partly because of the more expensive spark proof equipment necessary

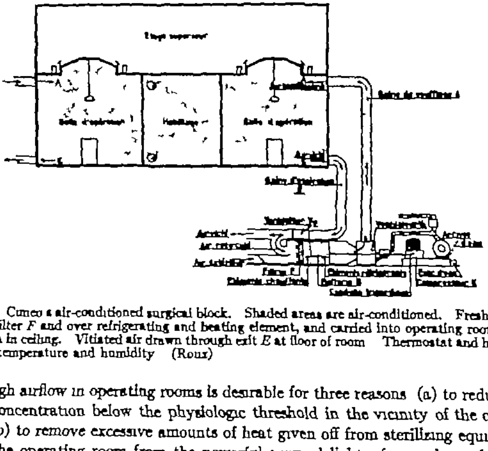


FIG 9 Cuneo's air-conditioned surgical block. Shaded areas are air-conditioned. Fresh air drawn through filter *F* and over refrigerating and heating element, and carried into operating room through opening *A* in ceiling. Vitiated air drawn through exit *E* at floor of room Thermostat and hygrometer regulate temperature and humidity (Roux)

"A high airflow in operating rooms is desirable for three reasons (a) to reduce anesthetic concentration below the physiologic threshold in the vicinity of the operating team, (b) to remove excessive amounts of heat given off from sterilizing equipment if inside the operating room from the powerful surgical lights, from solar radiation on walls and glass and from the bodies of the operators and (c) to allow extra capacity for quick preparation for emergency operations. A separate exhaust system is often desirable in order to remove gases and odors at the source. Good insulation of sterilizing equipment and thorough exhaust ventilation of sterilizing rooms adjoining operating rooms will help in reducing considerably the capacity and running cost of the cooling equipment" (fig 9)

Cleaning The operating room should always be kept thoroughly clean Between operations the floors are mopped. When the last operation of the day has been completed, the walls and floors are scrubbed and flushed with hot water from a hose. Furniture and equipment is wiped with a damp cloth and metal fittings are polished.

If the operating room has been contaminated by an infected case, it should be isolated, the furniture and floors washed with a germicide, such as a 5 per cent solution of cresol or phenol, and the room disinfected with formaldehyd introduced through the ventilator Beck (3) reports a clinic which carries out the following procedure: "Linen, instruments, gloves, and contaminated supplies are placed on the operating table by a nurse in gown and gloves and taken to a special work room, where linen and gauze are placed in a 10 per cent solution of cresol for one hour. Instruments and gloves are washed in cold water and boiled, instruments for fifteen minutes, gloves for ten Scalpels, pins, etc are placed in a 40 per cent solution of cresol for one hour The rubber

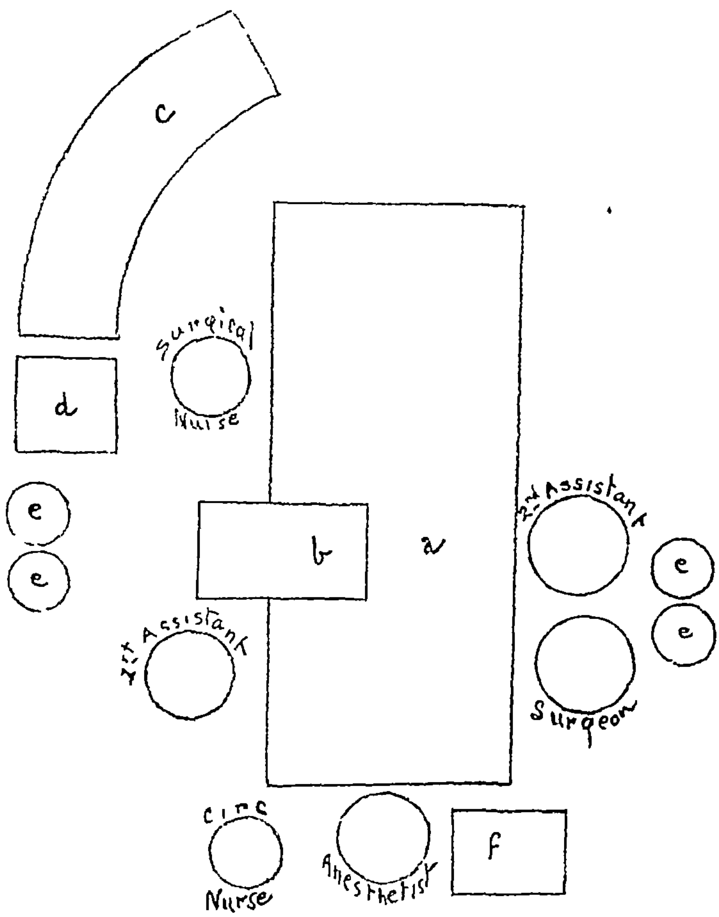


FIG 10 Diagram, illustrating convenient operating room arrangement *a*, operating table *b*, instrument tray *c*, reserve table *d*, suture table *e*, double basin stands for normal salt solution and alcohol *f*, anesthetist's supply table

pillow and operating table are washed with a 5 per cent solution of phenol The floor is mopped with soap and water and 5 per cent phenol The mop is treated with 5 per cent phenol and then sent to the laundry"

Equipment The nature and arrangement of the equipment in the operating room are governed largely by the requirements and personal preference of the operating room staff Briefly, the usual paraphernalia and its disposition is as follows (fig 10). (1) *The operating table*, covered with a stout boxed rubber pad and pillow, placed in the center of the room in such a position that a maximum of light will fall on the operative field, and adjusted to a height that will allow the surgeon to work comfortably If the table is not properly placed, incorrect angles of force are brought into play This will

lead to fatigue and eyestrain and seriously hamper the operative technic. The table should be durable in construction and simple in design to permit of easy and thorough cleaning, grounded to the floor so as to discharge any static electricity which may accumulate and electrically heated. It should be equipped with a hydraulic foot pedal for purposes of raising and lowering, and a geared wheel by means of which it may be adjusted to any position desired for a particular operation. Accessory apparatus includes stirrups, foot rests, anesthetist's screen, knee-crutches, shoulder braces, x ray attachments for fracture work, etc. (2) *An adjustable instrument tray*, which may or may not be attached to the table, and so arranged that at the time of operation it can be swung above the patient to the right of the surgeon. (3) A *table for reserve instruments and dressings*, placed to the left of the operating table. It may be rectangular or

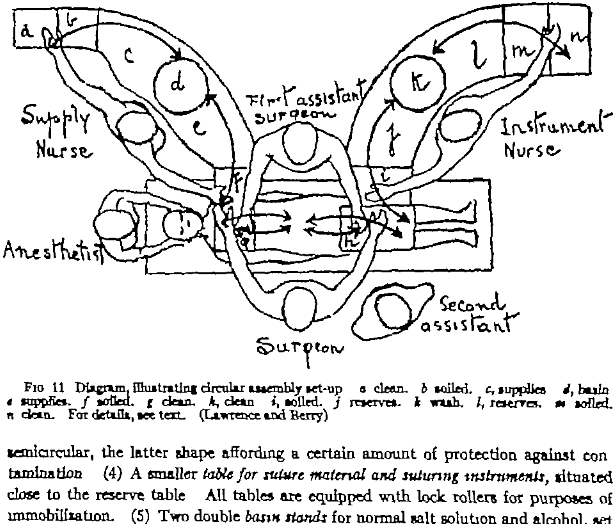


FIG. 11. Diagram, illustrating circular assembly set-up. *a*, clean. *b*, soiled. *c*, supplies. *d*, basin. *e*, supplies. *f*, soiled. *g*, clean. *h*, clean. *i*, soiled. *j*, reserves. *k*, wash. *l*, reserves. *m*, soiled. *n*, clean. For details, see text. (Lawrence and Berry)

semicircular, the latter shape affording a certain amount of protection against contamination. (4) A smaller *table for suture material and suturing instruments*, situated close to the reserve table. All tables are equipped with lock rollers for purposes of immobilization. (5) Two double *basin stands* for normal salt solution and alcohol, set behind the operator and assistant. (6) A *stand for drums* to hold sterile gowns, linens, sponges, etc., operated by a foot pedal and placed against the wall conveniently near the scrub-up room. (7) An *adjustable stool for the anesthetist and a table for his supplies* near the head of the operating table. (8) White enameled *buckets* to serve as receptacles for soiled linen and sponges, standing on rubber mats on the floor behind and to the right of the operator and assistant. (9) *Foot benches* of various lengths, shapes, and heights, conveniently arranged around the table. Included in the equipment should also be an irrigating stand for infusions, and some type of electrocautery machine

supplied with blades of different shapes for purposes of cutting, hemostasis, and the removal of infected tissues.

Lawrence and Berry (57) advise a circular assembly set-up with a standard arrangement of instruments as illustrated in Figure 11 The advantage of such an arrangement is that the "pre-location of instruments and supplies puts them at all times within the *normal grasping area* *Placing the instruments* and supplies on each side of the surgeon and the assistant favors development of 'two hand consciousness' Such an arrangement also enables the instrument and supply nurses to face the operative field at all times, avoiding the necessity of turning about to reach for the necessary article (ordinarily located behind them), and so lessens the danger of a break in aseptic technique on the part of the nurses, as well as eliminating useless motions The tables themselves are conveniently built with removable metal tops, which are readily sterilized The built-in basins are convenient for cleansing and replenishing and the division for clean and soiled instruments makes for delicacy in technique as only two places are soiled, and frequent changes of covers prevents the spectacle of a bloody operation Each of the commonly used instruments should have an exact prelocation and be arranged much as the keyboard of a console This should lead to the development of the touch system, enabling the surgeon and his assistants to reach for and grasp the desired instrument without taking his eyes away from the wound, much as a pianist or a typist striking his keys The instruments not so commonly used should be prelocated by the instrument nurse so that she can reach and grasp them, pass them to the surgeon without delay It is for these less commonly used instruments that hand signals prove most useful All things to be used by the individual should be within the normal grasping area The maximum grasping area should no more come into play in the operating room than at a well conducted dinner table Instrument and supply tables should be so arranged as to favor the use of both hands"

Sterilizing Room. The sterilizing room should be located near enough to the operating room so that instruments may be sterilized, transported, used, and returned quickly and with a minimum of effort, but far enough away so that the hissing sound of escaping steam will not reach the operating room when the doors are opened It is also advisable that it be at some distance from the instrument cabinets, since steam will rust instruments even when they are enclosed The equipment of the sterilizing room should comprise (1) an autoclave for the sterilization of dressings, (2) a small boiler for instruments, (3) a large utensil sterilizer with a hydraulic lift, (4) a water sterilizer, (5) two sterile water tanks, (6) a gas plate, and (7) a blanket-warmer All this equipment should be operated by means of foot-pedals as a precaution against scalding In the more modern hospitals sterilizers are built into the walls, only the valves, switches, gauges, and levers being visible For the comfort of the nurse and as a protection for the paint, plaster, and fixtures, the sterilizing room should be provided with an exhaust fan that will expel the heat and humidity

Scrub-Up Room. The scrub-up room is preferably located between the two operating rooms and should be large enough to accommodate two teams scrubbing up simultaneously The dimensions of the basins should average 36 x 60 x 10 cm , the water-tap spray being located 35 to 50 cm above the basin and operated by a foot or knee lever Alongside or above the wash basin should be a glass or marble slab on which are to be placed a basin of antiseptic solution containing sterile scrub-brushes, orangewood sticks, nail files, and scissors It is convenient to have separate dispensers of green

soap and alcohol, operated by a foot pedal. If antiseptics are used as a part of the scrubbing process, large arm basins should be placed within easy reach of the scrub-up stand.

Dressing Room. The dressing room where the surgeon and assistants change their street apparel for operating suits should be well ventilated and equipped with toilets, showers, dressing benches, wash stands, and mirrors. Locker compartments should be of ample size for the accommodation of clothing and valuables.

Anesthetizing Room. The anesthetizing room should adjoin the operating room but be so situated that the patient be spared the sight of groaning patients being transported in and out. The room itself should be large enough so that the anesthetizing table may be turned around, the doorway wide enough to permit of the passage of a hospital bed, for occasionally it is convenient to bring the patient to and from the operating room in his bed, and the walls sufficiently thick to exclude all sounds coming from the operating room. A radio or phonograph may be used to advantage to divert the patient's thoughts from the operative ordeal (p. 408). The equipment should include cabinets for the storing of spare cylinders, anesthetics, masks, tubing, catheters, syringes, supplies, and restorative drugs.

Recovery Room. It is advisable to include in the operating unit recovery rooms where the patients may be transferred immediately after operation and remain until complete recovery from the effects of the anesthetic. Such an arrangement reduces the incidence of postoperative pneumonia, permits of the application of emergency restorative measures without delay, and spares convalescing patients the ordeal of observing a vomiting, groaning patient recovering from anesthesia.

Work Room. The work room where dressings and bandages are prepared, instruments sorted, and gloves and other materials mended is a necessary adjunct to the operating suite. It should be large and airy and contain a sufficient number of cabinets for the storing of raw material. The usual fittings include a large measuring table, gauze-cutting machine, sewing machines, bandage rollers, knives, scissors, etc.

Masmonteil (66) describes an operating suite constructed and sterilized in the following manner (fig. 12). "The block consists of two operating cubicles, each with its smaller cubicle for administering anesthesia. There is a vestibule, extending the length of the entire block. The patient is taken to the anesthetic room and from there to the operating cubicle, the surgeon enters the room at one side of the vestibule, where he changes his street clothes, and then goes to the lavatory, where he sterilizes his hands and puts on his operating mask and gown. The doors between the lavatory, the anesthesia room and the operating room are sliding doors. In the lavatory the surgeon and his aides who are to enter the operating room are irradiated with ultraviolet light rays, from 350 to 400 μ wave length and the patient is irradiated with the same light in the anesthesia cubicle. The anesthesia cubicles are painted in blue and lighted with blue light, in these cubicles the nurses prepare the patient for operation and arrange the instruments for the surgeon's use so that they do not enter the operating cubicle only the anesthetist enters this cubicle with the patient. The operating cubicles are 6 by 4.5 meters and 2.5 meters high at the center, and 2.25 meters high at the periphery. This gives sufficient cubic capacity of air for five persons for an hour, most operations last for a shorter period, and the air is renewed after each operation by means of the ventilators. In the few operations that last longer than an hour, filtered air is admitted through the ventilators to give a constant supply of fresh air. The ventilators are so arranged that this

can be done without producing any current of air around the operating table The air is filtered and conditioned in an apparatus within the surgical block but outside of the operating cubicle The operating cubicles are oval in shape, as this improves the circulation of the air and facilitates cleaning

"The floor of the operating cubicle is of large slabs of stone, separated by joints 1 cm wide which can be cleaned easily The walls are double, with a space between the two parts containing radiators, the exterior part of this double wall is constructed of an insulating material, the interior part is duralumin, tinted electrically The ceiling is of glass supported by metal A circle of lights is in the ceiling, the rays of which are directed over the operating table by a concentration prism, this gives the optimum degree of light without dazzling To this lighting system is added an ultraviolet and

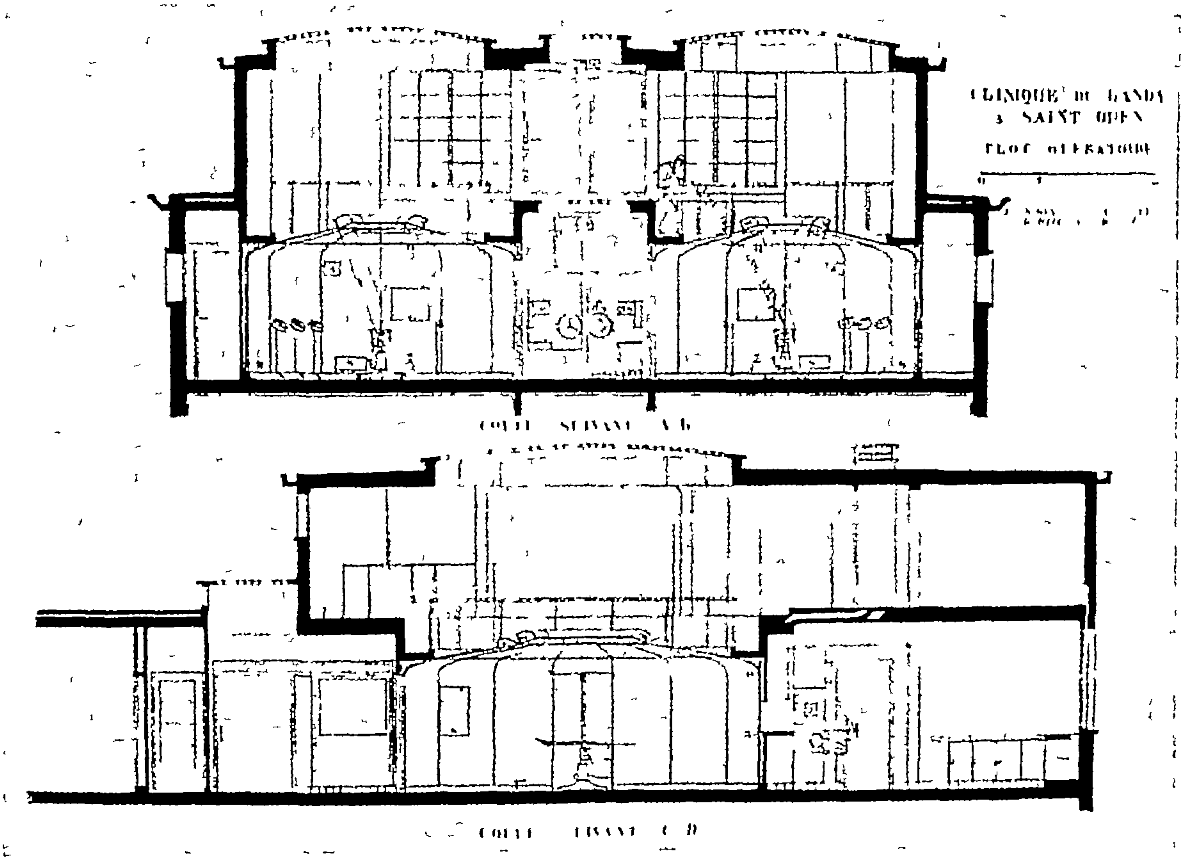


FIG 12 Sectional view of Masmonteil's operating suite For details, see text (Masmonteil, Rev de chir , 1937)

an infra-red light The former, with wave lengths of from 350 to 400 *u* is used for irradiation of tuberculous peritonitis and for its general antiseptic effect in septic operations, the latter for its effectiveness in reducing shock, as recommended by a number of surgeons in recent years

"The apparatus for the sterilization of dressings and instruments is also included in this block The walls of the surgeon's lavatory are largely of glass, so that he can observe the process of sterilization, and can also watch the preparation of the patient in the anesthetic cubicle There is also a small laboratory in the block, where specimens can be examined during the operation, and the sections prepared for later study At one side of the vestibule is a room for endoscopic examinations, and the reduction of fractures under roentgenological control, from which the light can be shut off, there

is a separate lavatory connected with this room At the other side of the vestibule there is a room for the reception of the patient after operation, where he is under the care of surgical nurses until he regains consciousness.

"The operating cubicles are cleaned and sterilized by the introduction of steam which is condensed and removed so that there is no collection of fluid on the walls, and the air is renewed after each operation After this procedure when the room was ready for operating, Petri dishes placed in various portions of the room have proved to be sterile, as no bacteria of any kind was obtained on cultures

"Measurements of the temperature and the humidity when the room was prepared for operation show the former to be 23.5°C , and the latter 48 per cent, which are re garded as conditions of 'maximum comfort.' "

Instruments

The essential requirements of all surgical instruments are strength of construction, simplicity of design, and capability of easy sterilization Saws, rongeurs rasps, knives, and scissors should be made of the best tool steel and forged filed, ground, and sharpened by hand. To insure against breakage instruments of delicate construction should be tempered, a process which increases the strength of the steel and at the same time reduces its hardness and thus permits of its bending Instruments which in their use demand a bending backward and forward must be annealed in order to completely remove the hardening Before resorting to the use of such instruments it is advisable to test their temper by drawing a file over their surface. If the file takes a bite it is evidence that the instrument is tempered, whereas if it slides off the surface it indicates that the steel is "glass hard" and will break on bending Stainless steel—an alloy of steel, chromium, and nickel—has the advantage of strength, ductility, and resistance to corrosion, rust, and tarnish but unfortunately this material is not adapted for cutting instruments

All instruments should be of such form and size as to permit of deft and comfortable manipulation Those of complicated design and adaptable to many functions, and especially those which incorporate an automatic quality, are best avoided, as they may cease to function at the most inopportune moment. To facilitate sterilization, all surfaces should be smooth, and locking instruments should be so constructed that they can be readily taken apart for purposes of cleansing

The number of instruments for any particular operation is best limited since accuracy, speed, and nicety of manipulation are more readily attained with a few carefully selected instruments than with a complicated assortment. Moreover, the more numerous the instruments, the greater the possibility of a break in the aseptic technic. As a matter of fact, there are few operations that cannot be performed in some way or another by the efficient use of merely a scalpel and a dissecting forceps

Care of Instruments. Surgical instruments require constant and meticulous care if their utility is to be preserved and the expense of their upkeep minimized. Immediately after each operation all instruments should be collected counted, and checked against the list made before the operation. Missing instruments like missing sponges, must be accounted for before the patient leaves the operating room If the surgeon prefers to use his own instruments, it is advisable that they be marked, so that they can be readily separated from those belonging to the hospital After the instruments have

been checked, they are sorted, those used for cutting, including needles, are set aside for separate cleansing, to prevent their being dulled by contact with the others They are then washed in cold running water for the removal of gross blood, jointed instruments being opened and detachable ones taken apart Syringes are cleansed with water aspirated into the barrel and then ejected After this cleansing the instruments are placed in a basin of warm soapy water containing washing soda or some cleansing powder and scrubbed individually with a soft brush until they appear clean, special care being taken to reach all the crevices and the inside of hollow instruments If these precautions are not taken, the albuminous material will coagulate and form a protective cover for the organism, so that even boiling will fail to effect sterilization After this scrubbing, the instruments are sterilized lest any infection be introduced into the instrument cabinet In order to prevent rusting, they should be dried with a warm, soft towel immediately upon their removal from the boiler, the heat being depended upon to dry the joints and crevices inaccessible to the towel The same purpose can also be effected by an immersion of the instruments in alcohol, as the evaporating effect of the solution will rapidly remove all moisture Syringes may be dried if the plunger is worked up and down several times Finally the instruments are assorted and wiped over with a light oil, a drop being instilled into each joint and into the lumina of all hollow instruments Hollow needles are treated in a similar manner and stilets introduced

Before being stored, the instruments should be inspected for evidences of rust and the condition of their bites, locks, springs, and cutting edges tested Rusty instruments are renickeled Bent instruments are best discarded since the temper is damaged and their further use incurs the danger of breakage Faulty bites, locks, and springs are repaired, and all dulled cutting instruments, such as knives, chisels, saws, and needles, resharpened The sharpness of a knife is determined by the ease with which it slits a French trial kidskin stretched on a drum Any degree of dragging evinced by the blade calls for resharpening The keenness of scissors can be tested by snipping the edge of the kidskin with the points and removing the instrument with blades closed If they are of the proper sharpness, no part of the instrument will drag and the incision will be clean Needles are examined with a magnifying glass and those with dull points are either discarded or sharpened on an emery cloth or oiled stone If a hypodermic needle has become plugged, it is attached to the syringe and water forced through it If this fails to clear the lumen, the plug can frequently be removed if the needle is held over a flame and pressure is applied to the piston Due attention should be given to syringes to determine whether their pistons work easily If they stick, boiling in glycerin frequently loosens them

Finally, in order to guard against deterioration by rust, the instruments are placed in air-tight, dust-proof, glass cabinets in a well-lighted room and at a safe distance from the steam sterilizer For convenience they are arranged in a definite order, either with regard to the service, such as eye, ear, and nose, etc —or in accordance with their function, as for cutting, suturing, holding, etc Since knives are easily dulled, even when not in use, it is well to store them in a box equipped with racks which will permit the blades to lie separately The cabinet should be furnished with a hygrometer for the recording of the amount of moisture present In order to minimize the humidity, a small porcelain dish containing quicklime may be placed on one of the shelves Since this agent deteriorates rapidly, its efficacy should be tested from time to time

This may best be accomplished if water is added and the reaction noted, failure of the powder to become warm is evidence that the lime is no longer effective To preserve the luster of the instruments no rubber goods should be stored in the cabinet.

Classification of Instruments *For the sake of convenience surgical instruments may* be classified as follows (1) instruments for cutting, (2) instruments for hemostasis, (3) instruments for exposure and exploration (4) instruments for holding tissues, (5) instruments for suturing, and (6) accessory instruments

(1) *Instruments for Cutting* For the dividing of soft tissues the following instruments are used (a) *Scalpels* Knives should be forged in one solid piece The handle should be so shaped as to permit of a firm hold and easy guidance. The most desirable handle is one 10 cm long and 0 9 to 1.2 cm. wide The tip of the blade may be blunt or pointed, and the belly straight or curved, narrow or wide, the choice depending upon

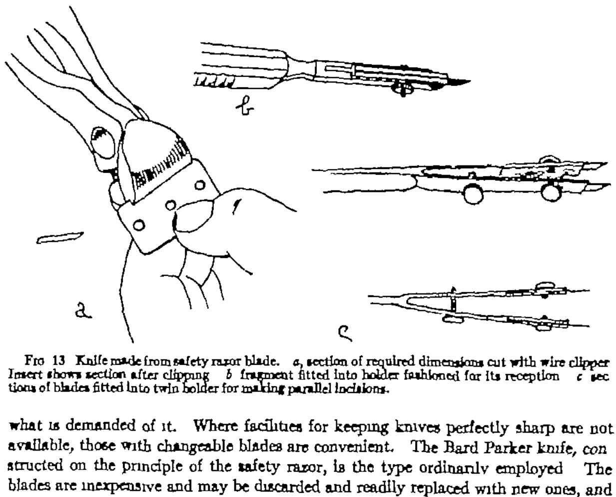


Fig 13 Knife made from safety razor blade. *a*, section of required dimensions cut with wire clipper Insert shows section after clipping *b* fragment fitted into holder fashioned for its reception *c* sections of blades fitted into twin holder for making parallel incisions.

what is demanded of it. Where facilities for keeping knives perfectly sharp are not available, those with changeable blades are convenient. The Bard Parker knife, constructed on the principle of the safety razor, is the type ordinarily employed The blades are inexpensive and may be discarded and readily replaced with new ones, and this obviates the necessity of sharpening They are obtainable in various sizes The #11 blade is pointed and is convenient for puncturing or paring of tissues, the #15 is reserved for delicate dissection, and the #20 to #23 are used for ordinary incisions. A valuable and economical knife may be made from a safety razor blade, a section of the required dimensions being cut with a wire clipper and the fragment thus freed fitted into a holder fashioned for its reception (fig 13) Knives have also been designed to meet special purposes, and these will be described in the sections dealing with their use. The prime requisite of all knives is sharpness. A knife that is not sharp is not only provoking to the surgeon but is also hazardous to the patient It inflicts unnecessary damage

by pulling and hacking the tissues, and its dulness increases the difficulty of gauging the correct force and direction of the blade In dissections around large vessels and nerves it is especially dangerous, as the undue effort required to incise the tissues may cause irreparable harm to these important structures If the knife becomes dull and if, for any reason, it cannot be replaced during an operation, it may be stropped on a sterile towel into which is rubbed a paste composed of fine carborundum powder and strained tallow (b) *Scissors* Scissors are made in many sizes and shapes, depending upon the service demanded of them The blades may be straight or they may be curved anteroposteriorly or laterally, the points may be blunt or sharp, or one point may be sharp and the other blunt, the lock may be screwed or morticed For ordinary purposes, the Mayo scissors, the blades of which taper down to a small blunt point, are probably the most useful variety Regardless of shape and size, scissors, like knives, should be sharp and the joints neither too tight nor too loose Although they are easier to manipulate and incur less danger to underlying structures than do knives, they are not recommended as substitutes for the latter, as the pinching and crushing incidental to their use traumatizes the tissues unduly Scissors are employed principally for the trimming away of dead tissues, for the cutting of sutures, ligatures, and dressings, and occasionally for blunt dissection For surgical purposes they are best held with the thumb inserted in one ring and the ring finger in the other, and the index finger placed on the lock to direct their course

The usual instruments employed for cutting bone and cartilage are the following. (a) *Bone-cutting forceps*, resembling in appearance wire-cutting forceps The jaws are strong and beveled to sharp edges like those of a curet and meet exactly when the blades are approximated They are used principally for the enlarging of small openings in bone, and for the trimming of uneven and overhanging bone ledges Rib-cutting forceps (costotomes) have a narrow curved blade with the cutting edge on the concave side, and a broad flat blade with the cutting edge on the convex side When closed they cut the rib scissor fashion Bone-holding forceps are a form of angulated or curved forceps with long serrated beaks, the apposing surfaces being grooved transversely They are used for the removal of dead pieces of bone or for the manipulation of bone fragments (b) *Saws*, available in various sizes and shapes Where the bone can be freely exposed, a hand-saw is employed, but where adequate exposure is impracticable, the hand-saw is substituted by a gigli saw, a heavy steel wire with a spiral cutting surface (c) *Drills*, required for making holes in bone They consist of variously-sized points, to be fitted into a handle equipped with a geared wheel, the drill being held in place with one hand while the force necessary to turn the wheel is furnished by the other (d) *Chisels*, such as those employed in wood carving and obtainable in a number of sizes and shapes The cutting edge, unlike that of an osteotome, which tapers equally on both sides, is beveled on one side only The handles are designed in such a way that the force can be applied either by the hand or by means of a mallet They are used for splitting off layers of bone If the chisel is held horizontally against the bone, thin layers are shaved off, and if held perpendicularly, portions of greater thickness are separated (e) *Gouges*, a type of chisel curved from side to side and procurable in different sizes, widths, and degrees of curvature They are used for cutting grooves in bone and are particularly adapted to the margins of cavities (f) *Mallets*, made either of wood or of steel and available in different sizes and shapes They are employed to supply driving power (g) *Periosteal elevators*, similar to small chisels and either blunt

or sharp The former are employed to raise non-adherent periosteum and the latter to separate adherent periosteum. (h) *Rasps*, patterned after the blacksmith's file and used for the scraping and polishing of bone (i) *Curets*, spoon-shaped instruments designed to scrape out infected cavities in bone. (j) *Probes*, employed for purposes of exploration and also valuable in the elevating of bone fragments.

Electrically operated instruments are convenient in certain types of bone surgery and come equipped with special attachments, such as drills, burrs, and circular saws. While these instruments are in use a constant stream of sterile normal salt solution must be allowed to flow over them to prevent overheating of the tissues

(2) *Instruments for Hemostasis (Hemostats)* Hemostats are instruments equipped with snap-catches and are employed to clamp bleeding vessels They are usually constructed with rounded points so that the ligature when tied around the vessel can be easily slipped off When applied to small vessels they frequently check hemorrhage and render ligation unnecessary, but on large vessels a ligature must be applied before these instruments can be safely removed. Occasionally they are used for purposes of blunt dissection, in which case they are inserted closed, and opened within the tissues Hemostats come in various sizes and shapes. Those most commonly used are (a) the Halsted forceps, with its jaws grooved transversely, (b) the Kelly hemostat, curved on the plane of its apposing surfaces (c) the mosquito forceps, a small, delicate instrument, the jaws of which are sharp and narrow and taper to a point, (d) the Kocher type, equipped with interlocking teeth, employed when there is need of holding the tissues securely

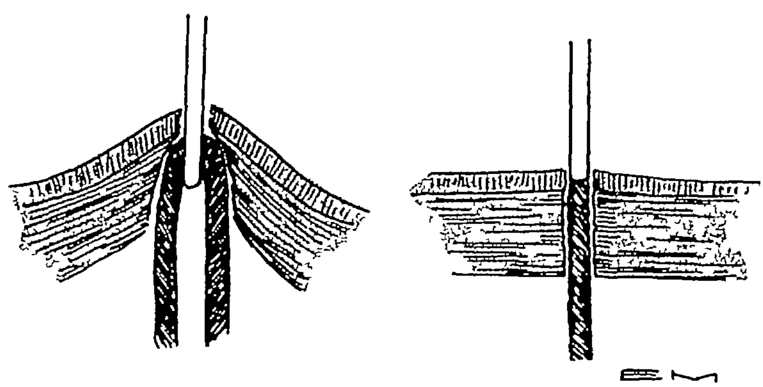
(3) *Instruments for Exposure and Exploration* (a) *Retractors* employed to hold the wound margins apart for the exposure of deep structures They come equipped with both blunt and sharp prongs Large-hooked retractors are used to draw tendons, nerves, and blood vessels aside, fine dural retractors with one or more prongs to retract and elevate skin and subcutaneous structures (When properly placed, however, traction sutures can frequently be made to replace retractors to advantage, as they do not encroach upon the field of operation.) (b) *Specula*, types of retractors used to hold open body cavities, such as the acoustic canal and the nostril. (c) *Mouth gags* for intra-oral surgery They take various forms, the choice depending upon the individual preference of the surgeon (d) *Probes and directors* in various lengths and diameters with blunt ends to avoid damage to the tissues They, likewise, are valuable for purposes of exploration (e) *Dissectors* dull instruments used for the separation of tissues in the vicinity of important structures, where a knife might prove dangerous

(4) *Instruments for Holding Tissues (Forceps)* Dissecting forceps may be plain or toothed. The plain variety (pick up or thumb forceps) have transverse or longitudinal corrugations on their inner surfaces and are designed to inflict a minimum of tissue damage. For additional tissue protection the points may be covered with a thin layer of cotton. They are used to grasp and steady tissues while incisions are being made or to free exposed structures from adherent connective tissue. Mouse-tooth forceps have interlocking teeth and while they hold the tissues more securely they cause considerable trauma. A special type of toothed forceps is the Allis forceps which have a snap-lock, resembling that of a hemostat. Tissue forceps are available in many sizes, the one most commonly preferred being about 10 cm long The spring should be so tempered as to give a sense of tissue resistance when the jaws are closed, but not so strong as to tire the muscles of the thumb The point should be broad enough to

permit of a firm grasp of the tissues, but not so broad as to prevent the picking up of a small fragment

(5) *Instruments for Suturing* Needles come in many styles and sizes, the choice depending partly upon the structures through which they are to pass and partly upon the preference of the surgeon Generally speaking, they should be of the smallest caliber capable of performing the desired function For most purposes long needles are better than short ones, as they permit of entrance to both lips of the wound at one time, are more easily pulled through, and require less manipulation with the needle holder

The component parts of a needle comprise an eye, a shaft, and a point The eye may be round, oblong, or oval and directed either anteroposteriorly (Mayo and intestinal) or laterally (31) But whatever the shape or direction of the eye, it should permit of easy threading and be as small as is consistent with the required suture, in order to inflict a minimum of trauma in its passage through the tissues The French or calyx-eyed needle is one provided with a split- or spring-eye which facilitates threading in that the suture can be inserted without the necessity of its being passed through



a b

FIG. 14 Diagram, showing advantage of atraumatic needle *a*, ordinary needle, causing considerable displacement of tissue *b*, atraumatic needle, by doing away with doubling up of suture, causing minimal displacement (Davis and Geck)

the eye An excellent needle, the use of which is prohibited only by its costliness, is the atraumatic type in which the suture is integrally united to the needle without the intervention of an eye (fig 14) This needle, by doing away with the doubling up of the suture as it passes through the eye, causes the least possible damage and does away with the need of threading

Needle shafts vary in length and caliber, depending upon the need They come straight and curved, round and flat, and with and without cutting edges Straight needles are used when the anatomy of the part permits, and curved needles where the shape of the part is such that recovery of the point is difficult The latter come in the form of $\frac{1}{4}$ circle, $\frac{1}{2}$ circle, $\frac{5}{8}$ circle, etc , to meet special needs They should be threaded from the concave side to prevent the suture from slipping The puncture made by a needle with a round shaft, whether straight or curved, inflicts the least injury, as the small hole is immediately plugged by the thread which follows (fig 15a) These needles are preferred for loose tissues, such as fat and muscle Needles with cutting edges enter the tissues more easily and are used for suturing skin, mucous membrane, and dense fibrous structures The cutting edge may be along the sides, along the anterior concave surface, or along the posterior convex surface If a needle of the first type is

employed the tissues are incised laterally by its passage and the tension induced by the tying of the suture will cause a gaping of the stitch-hole and consequent scarring (fig 15b) In the use of a needle with its cutting edge on the concave surface, the force exerted to pass the needle imparts a knifelike action and increases the size of the stitch-hole (fig 15c) For this reason a curved needle with its cutting edge on the convex side is the most desirable. The point may be shaped like a pyramid, a trocar, or a flat triangle with cutting edges (Hagedorn) (32) Whatever the shape, it must be sharp in order that it may penetrate the tissues with ease and smoothness.

Surgical needles may be sterilized by boiling or autoclaving If they are to be boiled, they are first run through a gauze pad or placed in perforated metal boxes If steam under pressure is to be applied, they are put up in packages before being put in the autoclave, or placed in glass tubes open at both ends and plugged with cotton to permit of the entrance of the steam into the interior

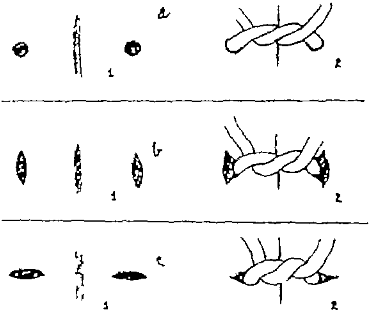


FIG 15 Effect of variously shaped needle shafts on tissues. *a* round needle leaves round hole, immediately plugged by suture. *b* needle with cutting edge along sides incises tissues laterally and causes gaping of stitch-hole when suture is tied. *c* needle with cutting edge on concave surface imparts knifelike action and increases size of stitch-hole.

Needles may be threaded either with forceps or by hand. In the latter case, they are held between the ring and little finger of the left hand while the suture is being passed through the eye with the right thumb and index finger, the left thumb and index finger being left free to grasp the end of the suture as it comes through the eye. A convenient means of fixing the suture in the eye of the needle is shown in Figure 16 After being threaded they are placed between sterile towels until ready for use.

Needle holders are used for the passing of curved needles (Straight needles can be introduced by means of the fingers and a thimble.) There are many types of holders, the choice depending upon the demands placed upon them and the surgeon's preference. The ordinary instrument consists of a handle curved to fit snugly into the palm, and stout jaws with apposed grooved surfaces to grip the needle securely A convenient holder is one such as that devised by Gillies, which combines the qualities of a holder and a pair of scissors The writer uses a holder similar to this except that the thumb-

ring lies at right angles to the other ring and thus brings the forceps into the axis of the hand and enables the surgeon to perform the suturing by a simple pronation and supination of the forearm Both jaws are hollowed, and in addition the upper jaw is fenestrated to permit of the passage of the needle at an angle when necessary Figure 17 is self-explanatory.

An ordinary hemostat is suitable for the passage of very small needles For the suturing of deep wounds a long slender holder is most convenient, and for cleft-palate operations a bayonetlike, curved needle holder is best A convenient instrument for the passing of sutures through dense tissue is Reverdin's needle It is mounted in a handle, and near the point there is an eye which can be opened by the manipulation of a lever at the base of the handle It is forced through both sides of the wound empty and with the eye closed, when it emerges, the eye is opened, the suture is inserted, and the eye again closed The threaded needle is then drawn back, leaving the suture in place

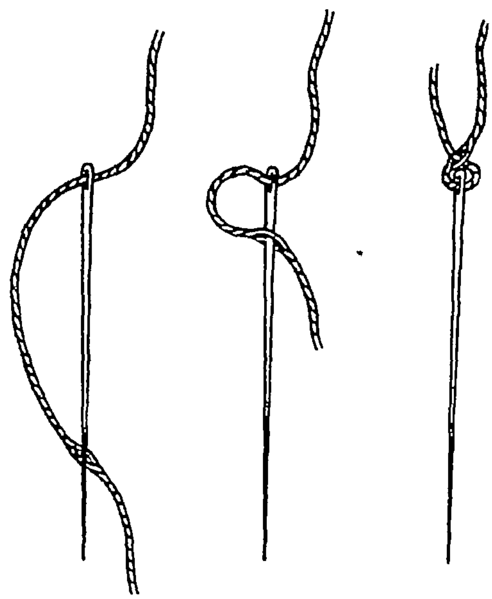


FIG 16 Method of securing suture to needle without knotting or rethreading Threaded needle passed between strands of suture material which is carried over eye of needle (Jett)

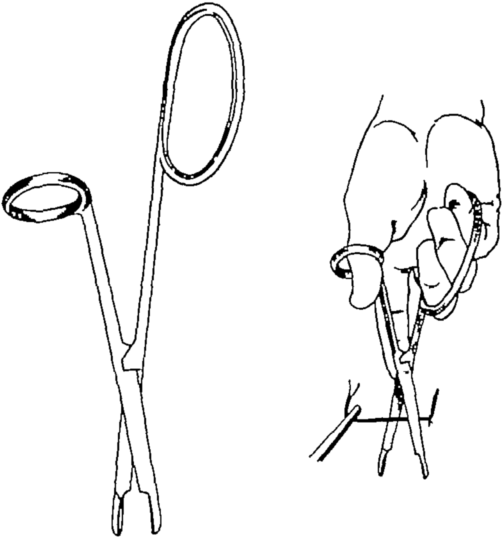
Vogel passes the suture material through a hypodermic needle previously introduced between the edges of the wound (fig 18)

Nelson (74) has devised an ingenious and rather elaborate instrument to facilitate the passage of interrupted sutures, and it is said to cause less trauma than the ordinary needle Essentially it consists of a hollow needle and a handle in which is lodged a wheel for propelling the suture material and a knife for cutting it The needle is first passed through the tissues, and the suture material is then forced through it by a turn of the wheel The end emerging from the needle is grasped, the knife is released in the handle to cut the thread, and the needle is withdrawn.

(6) *Accessory Instruments* (a) *Syringes*, described on page 409 They may be sterilized either by boiling or autoclaving. When the former method is to be used sodium carbonate should be omitted if the syringe is to contain procain because the alkali may adhere to the glass and inactivate the solution If steam under pressure is to be employed the piston and the barrel should be wrapped separately in gauze before being placed in the autoclave (b) *Trocar and cannula*, consisting of a tube (cannula)

encasing a sharp-pointed stilet (trocar), used for the aspiration of cavities. The instrument is introduced into the cavity and the trocar removed, leaving the cannula in place for the escape of fluid (c) *Sponge holders* a variety of long forceps with variously shaped ends, those most commonly preferred being ring or T-shaped. (d) A *loupe* for purposes of magnification, convenient for fine work (fig 91–2)

The number and type of instruments required for a typical operation vary in accordance with the preference of the surgeon, but since all operations involve incision,



a b

FIG 17 Combined needle holder and scissors. *a* thumb-ring lying at right angles to shaft of instrument enabling operator to pass sutures by simple pronation and supination of forearm. *b* instrument used to cut suture.

dissection, and closure, a *basic set* such as the one outlined below will serve to meet the general demands of all operations *Cutting Instruments*—1 Bard Parker handle #3, 1 Bard Parker handle #4 with blades #10 #11, #20, and #22 Scissors—1 straight Mayo 1 curved Mayo, 2 suture scissors. *Holding Instruments*—2 plain tissue-dissecting forceps, 2 mouse-tooth tissue forceps, 12 Allis forceps. *Hemostatic Instruments*—12 straight forceps, 12 curved forceps, 2 aneurysm needles *Suturing Instruments*—2 needle holders, assorted needles straight and curved assorted suture material silk #000, #0 #1, and #2, catgut #0, #1, and #2 *Retracting Instru*

ments—2 blunt medium-sized retractors, 2 sharp medium-sized retractors, 2 rake retractors, 2 dural retractors, 1 Kocher dissector, 1 probe *Miscellaneous Instruments*—12 Backhaus towel clamps; sponge-holding forceps, drainage material Additional instruments required for special operations will be listed in the appropriate sections.

It will be found convenient to have on hand a package containing the above instruments, together with an emergency supply of dressings and solutions already sterilized and sealed to avoid delay in case of urgent need

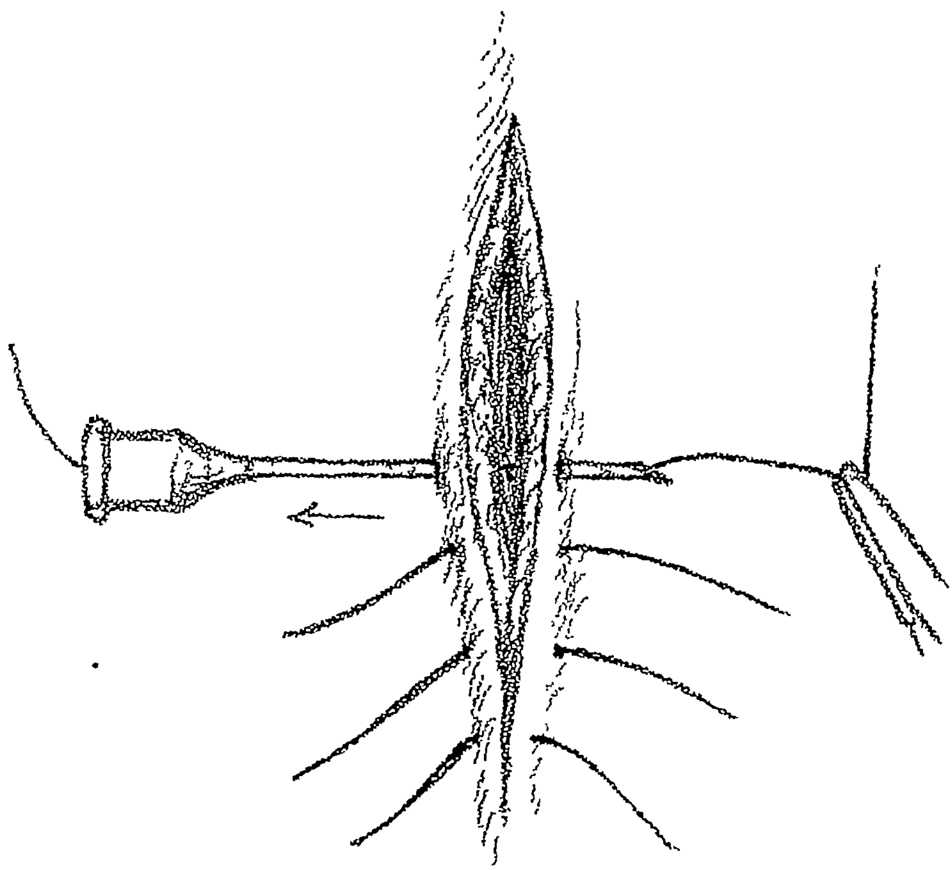


FIG 18 Passage of suture through hypodermic needle (Vogel)

Sutures and Ligatures

History records the suturing of wounds even in remote antiquity The Smith Papyrus, about 4,000 years old, discloses among other historical data evidence that the surgeons of Egypt approximated wound tissues by passing linen sutures through strips of adhesive tape attached to the sides of the wound In 600 B C Susruta is said to have closed abdominal wounds with strips of cotton and leather and with strands of animal tendons and horsehair In the first century A D Celsus described the suturing of wounds as a procedure already well established He wrote· "Suture is indicated if the lesion is a soft part, especially in the lobule of the ear or the ala nasi, or the forehead or cheek, the edge of the eyelid or the skin over the throat or the abdominal wall But if the wound is in the muscular part and gapes, and the edges can not be easily apposed, suture is contraindicated and fibulae [probably metal clips] are to be used in order that the cicatrix afterwards may not be wide . ." As to the suture material, he wrote: "Best made of soft thread not too hard twisted that

it may sit easier on the tissues, nor are too few nor too many of either of them to be put in." Rhazes (850–932 A.D.), the Arabian surgeon, is believed to have been the first to stitch an abdominal wound with catgut. Credit for the modern use of suture materials belongs to Ambroise Paré (1509–1590), court surgeon to Louis XIV.

Qualifications of Suture Material. The ideal suture material should possess the following properties: (1) Sterilizability, (2) tensile strength sufficient to ligate blood vessels, relieve tension, and hold parts together securely until organic union has taken place, but with the least cumbersomeness or rigidity, (3) absorbability without irritation, when organic union has taken place, (4) flexibility and softness, so that the suture will lie flat in the eye of the needle and not form a bulge requiring traction to bring it through the tissues, (5) smoothness to permit of its easy and rapid introduction into the tissues, (6) impermeability to secretions. While some sutures are endowed with many of the qualities mentioned above, unfortunately no one material incorporating all the requisites of the ideal suture has as yet been evolved.

Varieties of Suture Material. Suture materials fall naturally into two main divisions: (1) *absorbable sutures*, which are of animal origin, made from the intestines of sheep (catgut), kangaroo tendon, and fascia lata. Other absorbable materials, such as carnofil, nerves, and umbilical cord have been suggested, but their use is for the most part still in the experimental stage. (2) *Non-absorbable sutures*, which may be further classified as absorbent—notably silk, linen, horsehair, and Pagenstecher—and *non-absorbent* such as wire and silkworm-gut. Although this classification is convenient for purposes of description, the terms "absorbable" and "non-absorbable" are merely relative. For example, fine silk classified as a non-absorbable suture may ultimately disintegrate in the tissues, while hard catgut referred to as absorbable may become encapsuled and resist absorption.

(1) *Absorbable sutures* have the advantage that they are digested by the tissue juices and leukocytes, no trace of them remaining permanently in the tissues to act as foreign bodies. They usually disappear in from 1 to 4 weeks. Unfortunately, however, absorbable sutures, no matter how fine, occasion some degree of local tissue reaction with a consequent delay in healing. This reaction is attributed either to the breaking down of the insoluble collagen of the suture material into the soluble proteins during the process of absorption, or to the liberation of the chemicals with which the material is necessarily impregnated in the process of sterilization. While a suture of fine caliber usually causes a negligible amount of local irritation, one of a larger caliber produces considerable reaction, sometimes so pronounced as to result in a sterile abscess.

Catgut is prepared from the submucous layer of the terminal part of the ileum of sheep, and is widely used for ligatures and buried sutures. It is obtainable in various sizes, ranging from #000000 to #6, standardized according to its breakage point. For example, #00 has a tensile strength of 4 pounds, #0, of 7 pounds, #1, of 10 pounds, #2, of 14 pounds and #3, of 19 pounds. The rate of absorption depends partly upon the caliber of the material, the thicker the strand, the longer the time required for absorption. The nature of the tissues in which the suture is buried also plays a part: for example plain catgut #0 is usually absorbed within 9 days when placed in muscle, within 7 days in skin, and within 4 days in peritoneum. Inflammation and infection bring about an acceleration in the process of absorption and may cause the suture to yield before it has fulfiled its purpose. Therefore, if catgut is to be used in an infected field, due allowance must be made for this fact in the selection of

a strand of proper caliber Catgut is marketed both plain and chemically treated with agents such as chromic acid, tannic acid, iodin, etc, to delay its absorption Differences in the strength of the solutions applied and the duration of exposure produce varying degrees of absorbability, so that the process of absorption may last from 10 days to 7 weeks The principal *advantages* of catgut are its absorbability, its flexibility, and its great tensile strength However, there are many *objections* to its use (1) Its source renders it likely to be contaminated with anaerobic spore-forming organisms, such as the tetanus, gas gangrene, or anthrax bacillus The great problem is to secure sterility without impairment of the tensile strength of the suture or interference with its absorbability Sterilization by means of heat causes catgut to swell, soften, and become rigid on drying, and shortens its absorption rate Chemical sterilization is a complicated procedure which involves soaking, splitting, scraping, measuring, spinning, drying, polishing, grading, gauging, chromicizing, sterilizing, filling, sealing, and labeling, and even after the most careful preparation the resultant sterility is questionable Bulloch (9) found that more than 75 per cent of the catgut manufactured by eight English firms was non-sterile Knorr (49) discovered that 80 per cent of German commercial catgut contained bacteria. In the United States Meleney and Chatfield (70) found the products of seven suture manufacturers to be contaminated Clock (13) demonstrated that 62 5 per cent of 24 brands of foreign-made catgut were non-sterile, and that among 12 American brands 6 were repeatedly non-sterile, and was convinced that "chemical sterilization of surgical catgut by any method yet devised is insufficient and unreliable" Similarly, Konrich and Zeissler (52), after examining over 44,000 meters, came to the conclusion that there is no fundamentally sterile catgut It has been shown clinically that the incidence of suppuration following the use of catgut is three times that following the use of silk The difficulty of sterilization is probably one of the chief reasons why Halsted (33) was converted to the use of silk In view of the above, Mason (67) writes "The trend of surgical thought is that some standardizing agency should take control of the manufacture of ligatures, to the end that uniformity of sterilization and reliability may be obtained" (2) Like all absorbable sutures, catgut produces a local inflammatory reaction, especially when it has been impregnated with chemicals, and because of the relative thickness of the strand, a heavier needle is required, which inflicts additional trauma, retards healing, and favors infection (3) Catgut on account of its varying rate of absorption cannot be depended upon to preserve the coaptation of the tissues (4) Knots tend to become untied, due to the slippery nature of the material (5) Finally, the possibility of the patient's allergic sensitivity to catgut must be considered, and if he presents such a history, skin tests should be made before the material is employed.

The choice of tensile strength and absorption rate of the catgut to be used is governed by the character of the tissues that are to be approximated and the time required for their union As a rule, the finest strand capable of serving this purpose should be chosen, since the finer the strand, the more likely it is to be sterile, the less trauma it will inflict upon the tissues, the lighter the burden of absorption, the smaller the knot, and the less the likelihood of its slipping Furthermore, fine sutures are not so apt to be tied under great tension, and thus the risk of interference with the circulation of the part is minimized For this reason, when tensile strength is the chief requisite, it is better to use 2 or 3 strands of fine gut, rather than one single thick strand Generally speaking, plain catgut is employed for the approximation of subcutaneous tissues

in which healing is likely to be rapid, while chemically treated catgut is used chiefly for tissues in which healing is likely to be slow For the ligation of small arteries #0 to #1 plain catgut is advisable, for large arteries, #1 chromic catgut, for fascia, #1 20-day chromic catgut, for muscle #1 plain catgut, for fat, #00 plain catgut, for tendons, #0 and #1 chromic catgut.

Catgut already prepared and sterilized is available in sealed glass tubes, on the surface of which is etched the size of the enclosed strand, the mode of preparation, the rate of absorbability, and the method by which the exterior of the tube is to be sterilized—i e, "boilable" or "non-boilable." The outside of the tube is first cleansed with soap and water The boilable variety is sterilized either by boiling or by autoclaving for 30 minutes, but the non boilable must be sterilized in a germicidal solution since heat destroys the tensile strength of the suture and renders it too brittle for use. After sterilization the tube is wrapped in a sterile towel and broken The catgut is removed with a sterile forceps The boilable variety must be moistened to restore its pliability before it is threaded, and this is done either by immersing it for 10 seconds in saline solution at normal body temperature, or by placing it for 2 to 4 minutes, depending upon the size of the strand, in 70 per cent alcohol. The non boilable variety is sufficiently flexible when removed from the tube to require no moistening, provided it is used immediately In either case the catgut should be unwound gently and straightened by being grasped at each end firmly and subjected to a steady, even pull Sudden jerking is to be avoided, as it has a tendency to weaken the strand

Kangaroo tendon, obtained from the tail of a kangaroo, presents approximately the same advantages and disadvantages as catgut, but on account of its larger caliber it possesses greater strength and offers more resistance to absorption. It is available in 3 sizes—fine, medium, and coarse The fine has a tensile strength of about 27 pounds, the medium, about 38 pounds, and the coarse, about 50 pounds The use of this material is limited chiefly to bone surgery

Fascia lata, both autogenous and heterogenous (ox fascia), is employed as suture material. The autogenous variety is preferable and is obtained with a fascia stripper (p 198) It is cut into strands of appropriate size, threaded into the eye of the needle, and tied just below the eye with sterile silk or catgut to prevent its slipping

Carnofil is a flexible, wiry suture material obtained from muscle tissue of the horse It has been suggested as a substitute for catgut because of the difficulty involved in the sterilization of the latter material. In its original state it is said to be free from bacteria and capable of withstanding unlimited sterilization without impairment of its properties (82) It is absorbable and will not produce anaphylactic reactions except in sensitized animals (7) A strand of 0.5 mm. in diameter has a tensile strength of 1.5 kilograms, and a strand 0 8 mm. in diameter that of 11 kilograms

Other absorbable sutures made from organic material have been resorted to, notably dog's nerves (78) and umbilical cord (86)

(2) *Non-absorbable sutures* may be (a) *inorganic*—e g, silver, gold, bronze, and aluminum wire, and alloys of these metals (b) *organic*, which may be either of animal origin—e.g, horsehair, silk dermal suture and silkworm-gut, or of vegetable origin, linen and Pagenstecher (celluloid thread) Non absorbent sutures have two great advantages over absorbable sutures, in that they can be sterilized by boiling and are non-irritating to the tissues. In the past their use was confined to the approximation of surface wounds but recently, owing to the general dissatisfaction with the un

sterilizable catgut, there has been a tendency to rely on them for the subcutaneous closure of clean wounds

Inorganic Sutures Suture material in the form of gold, silver, bronze, and aluminum wire and alloys of these metals are strong, non-absorbent, capable of easy sterilization, can be tied by an ordinary knot, and are available in various calibers The chief objection to their use is their tendency to kink and to cut through the tissues Babcock (1) advocates the use of rustless steel, an alloy of steel, chromium and nickel, which has been annealed and drawn into fine wire He claims that it is strong, smooth, inexpensive, remains indefinitely in the tissues without irritation or tarnish, and is so flexible that it can be tied in a knot as fine as silk He found on reopening wounds in which this material had been used that there was no evidence of fibrosis, irritation, discoloration, or pus formation It is marketed in #18 to #36 B and S gauge The #35 and #36 have the caliber of a hair and a tensile strength of $2\frac{1}{2}$ pounds, will conveniently replace dermal, silk, or horsehair sutures in fine plastic work, and are adaptable to the tying off of small blood vessels The #30 to #32 correspond in size to #000 or #0000 catgut and are suitable for uniting fascia, #18 to #22 are used in bone surgery Metal clips are also employed for skin closure, but are suitable only on unexposed surfaces, as they have a tendency to leave conspicuous scars

Organic Sutures *Plain silk* is marketed in a variety of sizes, ranging from the finest split strands to thick braided or twisted cords, either bleached white or dyed black. The great tensile strength of silk permits of the use of relatively fine strands and small needles, thus limiting tissue trauma It can be tied in small knots with little tendency to slip, thus it insures a greater security in hemostasis and reduces to a minimum the amount of foreign material remaining in the tissues When necessary, fine silk can safely be buried in the tissues, as it becomes encapsuled and sets up no foreign body reaction The atraumatic technic demanded in its use favors wound healing Finally, it can be sterilized by boiling

Clinical and experimental studies have shown that wounds heal more readily when sutured with silk than catgut Therefore, silk is being used with increasing frequency, both on the surface and subcutaneously (108, 1, 79) Recourse to this material, however, demands the strictest possible attention to asepsis When silk is buried in a sterile field, it becomes encapsuled and in time disintegrates without untoward tissue reaction, but in the presence of infection it acts in the manner of a foreign body, is soon invaded by organisms, and forms sinuses which persist until the offending suture is extruded or removed, yet Halsted (33) said· "If fine silk were used and the infection slight, probably none of the buried sutures would be extruded nor would healing be delayed demonstrably on account of their presence When heavy silk has been used for any of the sutures and the suppuration is considerable, one or more, perhaps all of the threads would have to be removed Even in such a case it is very unlikely that the ligature and fine sutures would give trouble". Shambaugh (85) in controlled experimental studies also found that wounds sutured with silk tolerate bacterial infection better than those repaired with catgut, that healing is not appreciably delayed by buried silk sutures, provided a fine grade is chosen and the material is cut close to the knot He further demonstrated that suppurating wounds repaired with silk may heal completely without removal or spontaneous discharge of the suture

As has been said before, a meticulous atraumatic technic is essential for good results with this material Only freshly sterilized silk of the finest caliber consistent with

the need should be employed. Continuous and constricting sutures, mass ligation, crushing of tissues, careless hemostasis and rough blunt scissors dissection is to be eschewed. Moreover, the use of both silk and catgut in the same wound should be avoided (33) If there is any doubt as to asepsis or to the atraumatic technic, it is probably safer to forego the use of silk.

Silk may be *sterilized* either by being autoclaved for 15 minutes at 10 pounds pressure, or by being boiled in water for ½ hour Before it is placed in the sterilizer, 2 or 3 layers are wound on small glass reels, care being taken that it be done loosely, otherwise, the expansion of the glass and the contraction of the silk by the heat will weaken the thread Inasmuch as repeated sterilization with heat tends to reduce its tensile strength, only a small quantity sufficient for immediate need is sterilized at one time. Boiling in a light mineral oil has been suggested as superior to boiling in water for purposes of sterilization, because it is said to be less destructive to the silk. Onodera of Japan sterilizes silk chemically by soaking it in an aqueous solution of hydrogen peroxid.

Paraffined or waxed silk is stronger, smoother, and more easily threaded than ordinary silk, and has less capillarity and less tendency to fray It is prepared in the following manner Ordinary silk is wound loosely on glass bobbins and soaked for 30 minutes in white paraffin or beeswax at a temperature of 240° F The excess paraffin or wax is drained off and the coated silk sterilized by the fractional method (p 48)

Silkworm gut is essentially unspun silk and is obtained from the silk forming gland of the silkworm It is a stiff, strong, smooth material resembling spun glass, and is available in fine, medium, and coarse strands about a foot in length, white or black in color Unlike silk, it is not composed of fibers, therefore, it is not absorbent and the fluid from the wound cannot soak into its substance. It is non irritating and can be left on the surface longer than silk. Its perfect smoothness facilitates its introduction and removal. Although it is stiff and somewhat difficult to tie, once tied it molds itself to the position it is made to assume, a single turn of the knot often sufficing to hold it. It finds its greatest usefulness for skin tension sutures A very thin variety, known as ophthalmic gut, is especially adaptable for surface sutures in cases where an inconspicuous scar is particularly desirable The principal disadvantages of silkworm-gut are its flatness its limited length, its lack of elasticity, and the variations in diameter within a single strand. Silkworm-gut is sterilized by being boiled for 15 minutes and is stored in 4 per cent iodin for 5 days Before it is used, it can be rendered more pliable and less prone to split if it is allowed to soak in sterile warm water for 10 minutes.

Dermal suture is made of carefully selected pure silk threads or vegetable fibers and is finished by a special process. Its tensile strength is twice that of horsehair of the same caliber Its use is limited to the approximation of skin wounds. It is sterilized in an autoclave for 1 hour and boiled for 3 minutes immediately before use.

Horsehair obtained from the tail of a horse, is light, flexible, smooth pliable, relatively non-capillary and, since it is sufficiently elastic to expand and contract with the tissues, it has little tendency to cut through. Its preparation is as follows It is first cleansed with hot water and green soap and the fat extracted with ether, it is then sterilized in 1 1000 bichlorid, after which it is wound on spools and stored in 95 per cent alcohol. It may also be stored dry and sterilized just before needed by boiling,

sterilizable catgut, there has been a tendency to rely on them for the subcutaneous closure of clean wounds.

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which should not exceed 5 minutes, as a longer period tends to make it brittle Horsehair suture finds its chief application for the closure of skin and mucous membrane wounds

Plain linen thread is available in 4 sizes and 2 colors It is stronger than silk of corresponding diameter, hence it can be used in smaller sizes However, it frays more easily than silk and lacks the latter's smoothness, presumably causing more trauma when passed through the tissues *Pagenstecher suture* is linen thread which has been impregnated with celluloid for the purpose of rendering it non-capillary It is available in fine, medium, and heavy strands Ordinary linen sutures can be sterilized without deterioration by being boiled in water for 15 minutes, but Pagenstecher should be autoclaved, since boiling tends to harden it

Solutions

All solutions employed in the operating room should be carefully labeled, preferably with the name and percentage of the agent etched on the container As an additional precaution, toxic solutions should be colored

Antiseptic Solutions. (1) *Halogens and Their Derivatives* *Iodin* is employed as a 3 per cent solution in alcohol in the preparation of the skin for operation When it is used in this capacity, the customary preliminary scrubbing with soap and water should be omitted, for reasons already given (p 7) Iodin is of little value in the prevention of infection in open wounds, as it combines with the albuminous secretions which destroy its antiseptic properties, although it is said to promote phagocytosis and to stimulate the growth of granulation tissue *Dakin's solution* is a buffered aqueous solution of sodium hypochlorite It is prepared in the following manner 140 grams of dry sodium carbonate are dissolved in 10,000 cc of water, and 200 grams of chlorinated lime added After the mixture has been well shaken, the clear solution is siphoned off, filtered through cotton, and to it are added 40 grams of boric acid Since the solution is unstable, it must be freshly prepared and frequently titrated so that its chlorin percentage and hydrogen-ion concentration may be ascertained Dakin's solution, if properly used, is a potent antiseptic and a solvent for necrotic tissue But since its tendency to combine with albuminous discharges soon renders it ineffectual, it must be changed at least once an hour It is most efficacious when Carrel's technic is followed (p 276) *Azochloramid* (N-N-dichlor-azo-di-carbon-amidin) is a synthetic chlorin compound with antiseptic qualities similar to those of Dakin's solution It has many advantages over the latter agent, however, inasmuch as it is easier to prepare, more stable, does not irritate the skin, and retains its activity in the presence of albuminous secretions In addition, it gives off its chlorin more slowly, thereby rendering the dressing effectual for 24 to 48 hours But unlike Dakin's solution, it does not dissolve dead tissue It is used in concentrations of 1 3300 in saline or 1 500 in triacetin, the former being chosen principally for wet dressings or for irrigating purposes *Iodoform* is said to exert its antiseptic properties by liberating iodin in the tissues It is impervious to x-rays, and this fact should be borne in mind when radiograms are to be made Another objection to its use is its tendency to produce a dermatitis resembling erysipelas

(2) *Salts of Heavy Metals* All salts of the heavy metals have antiseptic properties The ones most frequently employed in surgery are corrosive sublimate and biniodid of

mercury *Corrosive sublimate* in 1 1500 solution is an efficient antiseptic, but is irritating to the tissues, inactivated by contact with albuminous secretions, and toxic when absorbed. It discolors steel and is decomposed by soap and alkalies *Biniodid of mercury* (potassic mercuric iodid) is a weaker antiseptic, but its toxicity is less than that of corrosive sublimate. It possesses good powers of penetration and does not stain or corrode instruments. Because inorganic mercurial compounds irritate the tissues, become inactivated by contact with albuminous secretions, bring about toxic symptoms when absorbed, and are incompatible with alkalies and acids, they have been largelv supplanted by organic compounds of mercury, most of which are marketed under proprietary names. They are all prepared in solutions of water, acetone, or alcohol for instance, mercurochrome (dichrome-oxy mercuri-fluorescein) is used in a 2 to 10 per cent solution, metaphen (nitro-hydroxy mercuri-orthocresol) in a con centration of 1 1000 to 1 10,000 and merthiolate (sodium-ethyl-mercuri-thiosalicylate) in 1 1000

(3) *Coal Tar Derivatives* In the distillation of coal tar many compounds possessing antiseptic properties are developed, the most familiar being phenol and lysol *Phenol*, first introduced into surgery by Lister, has lost its popularity and is rarely used today because of its caustic action on the tissues and its irritating effect upon the kidney after absorption It finds its greatest application in the sterilization of instruments, inasmuch as it does not corrode or discolor metal. Instruments thus sterilized, how ever, must be thoroughly rinsed in alcohol before they are used, as a precaution against burning of the tissues. *Lysol* (cresol) is cheaper than phenol and possesses twice its antiseptic power but aside from this fact it has the same objectionable features.

(4) *Dyes* There are many dyes with antiseptic properties. These agents are capable of acting in extreme dilution, are not inactivated by contact with albuminous secretions, and are relatively non toxic. *Flavin* is an anilin dye employed in 1 1000 solution Although it is not irritating to the tissues, it inhibits the formation of granulations and hence delays healing Therefore if it is used, it should be applied before granulations appear—for instance, in the packing of a wound where a delayed primary suture is contemplated

(5) *Oxidising Agents* These agents are said to exert their antiseptic properties by the liberation of oxygen They are rendered ineffectual by contact with albuminous secretions, as has been shown by Garrod and Keynes (25) who state that the activity of potassium permanganate was reduced 95 per cent by the addition of 5 per cent of blood to the test mixture, while that of hydrogen peroxid was canceled altogether *Hydrogen peroxid* is applied principally to suppurating cavities, but here a theoretical objection to its use is that the bombardment of oxygen gas serves to drive the infection into the deeper tissues It is also valuable for the removal of débris from wounds and for the loosening of adherent dressings *Potassium permanganate* in a 5 per cent solution possesses antiseptic properties similar to those of hydrogen peroxid. Meleney (71) believes that *zinc peroxid* is superior to other oxygen-producing antiseptics because of its slow constant delivery of oxygen to the tissues, and suggests its use in wounds likely to be contaminated with anaërobic bacteria. He recommends it especially for chronic undermining, burrowing ulcers due to anaërobic micro-aërophilic hemolytic streptococci. He applies it to every part of the infected surface as a creamy suspension in sterile water, and in order to prevent evaporation he seals the entire dressing with vaselin ointment.

(6) *Other Antiseptics.* Alcohol is a valuable germicide and is most efficacious in a 70 per cent solution by weight (p 6) It is especially applicable to skin sterilization, inasmuch as it acts not only as an antiseptic, but also hardens the skin and fixes the bacteria in the glands and follicles The combination of scrubbing with soap and water followed by the application of alcohol is probably the most effective method of skin preparation (p 7). *Picric acid*, in a 3 per cent solution in alcohol, is also used for skin sterilization and is less irritating than iodin *Boric acid* is feebly antiseptic and is applicable chiefly to the irrigation of mucous membrane and to fomentations *Formalin*, a 40 per cent watery solution of formaldehyd, is employed in strengths varying from 1 to 10 per cent Its principal drawback is its disagreeable odor.

Stock Solutions. In addition to the antiseptic solutions already mentioned, certain stock solutions are kept in the operating room, sterilized, and ready for use *Distilled water* is resorted to freely, both as a cleansing agent and as a vehicle for the various solutions It is sterilized by the fractional method, i e, it is autoclaved for 30 minutes on 3 successive days The first sterilization destroys the bacteria but not all of the spores; the second destroys the bacteria which have developed in the course of 24 hours from the remaining spores, and the third is carried out merely to insure safety

Normal salt solution is prepared by dissolving 0 85 gram of sodium chlorid in a liter of freshly distilled water The solution in this concentration is isotonic with the blood and for irrigation purposes is superior to sterile water, in that it is less irritating It is administered parenterally for the restoration of fluid balance in cases of dehydration, shock, and hemorrhage (p 349) Certain precautions should be taken in the preparation of salt solutions The container should be stoppered with sheet rubber or with a beaker inverted over the top of the flask The salt should be chemically pure, and salt tablets should be avoided, because of the harmful effects produced by the cohesive material added in their manufacture All necessary apparatus must be clean and the solution fractionally sterilized

Glucose solution is employed parenterally, and care must be taken in its preparation and administration, to avoid unfavorable reactions The strength of the solution will depend upon the indications (p 351). It is prepared as follows· The required quantity of pure glucose is dissolved in a small amount of hot sterile water, after which it is filtered for the removal of any impurities, poured into a flask, and enough sterile water added to give it the proper strength It is then boiled for 10 minutes All solutions showing evidences of caramelization or sedimentation should be discarded In case of an emergency, prepared ampules of glucose in doubly distilled water may be used

Wearing Apparel, Sponges, Dressings, Bandages, and Drapes

Wearing apparel comprises essentially operating suits, caps, masks, gowns, shoes, and gloves Operating suits, to be worn under the sterile gown, consist of a short-sleeved jacket and a pair of trousers gathered at the waist by means of a tape shirr-string, and are made of white drill, duck, or linen Caps are donned by all persons in the operating room as a precaution against the falling of scalp scurf on sterile material They are made of white cotton or linen and should be so fashioned as to fit snugly and cover the hair completely Masks are indispensable for all in attendance for the prevention of droplet contamination of the wound from the nose and mouth (p 12).

The customary mask is made of 4- or 6-ply bleached muslin, is 20 cm long and 15 cm. wide, and is provided with two sets of tapes to be tied behind the head, one set above and the other below the ears. The helmet type mask encases the entire head, with an opening for the eyes. Into this opening is sewn a piece of metal to prevent the steaming of eyeglasses.

Operating gowns should be large enough to overlap in the back and long enough to reach well below the knees The sleeves terminate in a band of stockinette that hugs the wrist as a protection against glove contamination The back of the gown is equipped with tapes, so that it may be tied from behind by an unsterile nurse It should be so folded that it may be opened and donned without danger of contaminating its outer surface. Operating shoes are made of white canvas or rubber, cloth leggings will serve the same purpose Rubber gloves should be made of good quality rubber, should fit properly, and be thin enough not to interfere with the sense of touch. Immediately after use they are soaked and scrubbed in warm water, after which they are wrapped in muslin, and boiled for 5 minutes. To determine the presence of puncture holes they are filled with water or air and compressed. Defective gloves are laid aside for mending, and sound ones are dried on the outside, reversed, dried on the inside, and powdered with chalk or talcum The cuffs are then turned down and each glove wrapped separately in muslin and placed in a cloth envelope together with a gauze packet of talcum powder for dusting the hands before the gloves are donned Such a packet is safer than the ordinary dusting can, since a break in aseptic technic on the part of a single member of the operating team will contaminate the can for those using it subsequently Rubber gloves are sterilized either by being autoclaved for 15 minutes at 15 pounds pressure, or by being boiled for 10 minutes in plain water

Sponges variously termed in different clinics as flats squares, packs, mops, wipes, pads, rolls, etc., are used during the operation for clearing wounds of extravasated blood and as tampons to staunch hemorrhage. The chief requisites are that they be absorbent, non-abrasive, free from loose ends capable of easy sterilization, and of the proper thickness. If too thin, they are valueless, and if too thick, they are difficult to manipulate Sponges come in a variety of sizes and shapes The simplest are those made of plain gauze folded in squares of 5 to 10 cm., the raw edges being turned in to avoid the loosening of threads in the wound. Those to be used in body cavities are tethered by means of a tape in which is incorporated some radio-opaque substance, such as a metal disk, to facilitate their identification if lost.

Many procedures are in use to prevent the loss of sponges in body cavities The usual method consists in wrapping them in bundles containing a definite number, counting them before sterilization and again just before use As they become soiled, they are hung on numbered hooks on a rack so that the surgeon can see at a glance that the count is correct. At the completion of the operation they are checked against the original number and signed for both by the surgeon and the nurse in charge As a substitute for separate sponges the use of a long roll of gauze has been suggested, the loose end being used in the wound. When soiled the end is cut off and discarded

Dressings are utilized for the protection of the wound from mechanical damage, the prevention of infection, the absorption of discharges, and the immobilization of the area They should be so applied as to support but not constrict the part. The requirements of a satisfactory dressing are that it be soft, absorbent, capable of easy

sterilization, and economical The materials most commonly employed are absorbent cotton and gauze The former material is resorted to principally for padding purposes, as in the application of a splint It is never placed in direct contact with the wound, since it absorbs discharges poorly, becomes packed down, macerates the skin, and adheres to the wound Gauze dressings are employed either as pads or in the form of fluff-gauze obtained by the crumpling up of squares of the material, the latter being especially valuable in oozing fields The use of medicated dressings has been generally discarded In aseptic wounds they are unnecessary, and in septic wounds they are more harmful than beneficial, inasmuch as a germicide of sufficient concentration to destroy bacteria would probably have a deleterious effect on the tissues themselves. Iodoform gauze is said to owe its efficacy to the liberation of iodin Since iodoform in a dry state is capable of harboring bacteria, the gauze should be sterilized before being applied Vaselin, xeroform, and paraffin gauze are used as non-adherent dressings for granulating wounds and skin grafts They are prepared as follows. A layer of gauze is placed in a porcelain dish and covered with the lubricating agent, which in turn is covered with another layer of gauze and so on until the container is filled The pan is then covered and placed in an autoclave for 1 hour, the heat serving the double purpose of saturating the gauze with the lubricant and sterilizing the dressing Other non-adherent dressings are silver leaf, oiled silk, waxed paper, paraffin paper, and cellophane, all of which can be sterilized by being autoclaved for 20 minutes Marine sponges are serviceable as pressure dressings and are sterilized in the following manner New sponges are first soaked in warm water for 24 hours for the removal of the gross grit, placed for 12 hours in a 5 per cent solution of hydrochloric acid for the elimination of calcareous matter, washed in running water for 12 hours, and finally sterilized chemically for 12 hours in a 1:1000 solution of bichlorid of mercury, 5 per cent phenol, or 20 per cent sulphurous acid

Bandages are used to keep dressings from slipping, to exert pressure on the wound, and to secure immobilization They are made of muslin, gauze, or flannel and may be impregnated with starch, plaster of Paris, or water glass Adhesive strips are employed to support the dressings Before they are applied, the skin should be shaved to facilitate their removal They can be made to adhere more securely if the skin is first wiped with tincture of benzoin or if the adhesive tape is warmed over a flame

Drapes are applied around the edges of the field of operation and comprise ordinary cotton towels, plain sheets, and laporotomy sheets, the latter being provided with a slit for the exposure of the line of incision Drapes are usually white in color, but some surgeons prefer green, blue, or gray in that they are more restful to the eyes

The Incision

In view of the elective nature of the operative wound, advantage should be taken of the opportunity to conserve the original anatomic configuration of the area and to inflict the least possible damage on the tissues For a strategic planning of the incision a thorough knowledge of the anatomy of the parts is essential The depth and thickness of the underlying tissues, the position of vessels, nerves, tendons, ducts, and other important structures, and their relation to the pathologic tissue must be visualized in order that accidental injury may be averted For example, where the

lesion lies beneath a large vessel or nerve, the incision should be made parallel to the course of the structure.

The incision must be of adequate *length* to permit of thorough exposure of the parts to be dealt with If too long, it not only inflicts unnecessary trauma but also leaves a needlessly lengthy scar, on the other hand, if too short, it complicates the operation, entailing either a great deal of cutting in the dark with its attendant hazards, or else a strong retraction of the wound edges, with the inevitable bruising and laceration

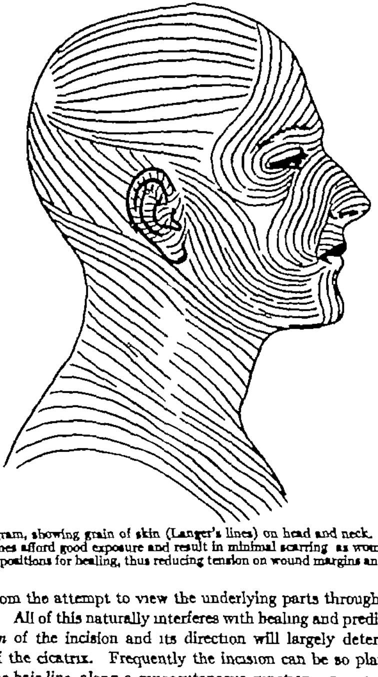

FIG 19 Diagram, showing grain of skin (Langer's lines) on head and neck. Incisions made along these cleavage lines afford good exposure and result in minimal scarring as wound edges fall naturally in advantageous positions for healing, thus reducing tension on wound margins and stress on sutures

inseparable from the attempt to view the underlying parts through an opening which is too narrow All of this naturally interferes with healing and predisposes to infection.

The *location* of the incision and its direction will largely determine the ultimate appearance of the cicatrix. Frequently the incision can be so planned as to conceal the scar in the hair line, along a mucocutaneous junction, or in a natural shadow or groove—for example, along the submammary or nasolabial fold Where the location of the lesion prohibits such concealment, disfigurement will be minimized if the incision is made along the "grain of the skin," easily recognizable by the inclination of the hairs and the course of the natural creases. The *grain of the skin* is the same in all individuals On the face its course is in the direction of the normal wrinkles, on the

neck it proceeds obliquely and transversely, on the trunk it follows the line of the ribs, on the abdomen it is fan-shaped and radiates downward and inward, and on the extremities it runs obliquely from behind forward Figures 19–22 are self-explanatory. The grain of the skin was plotted out by Eschricht (21) (1837) and Voight (97) (1857) Langer (55), a Viennese anatomist, later (1861) studied the effects of tension by making holes in the skin of cadavers and noting the direction in which these holes were pulled

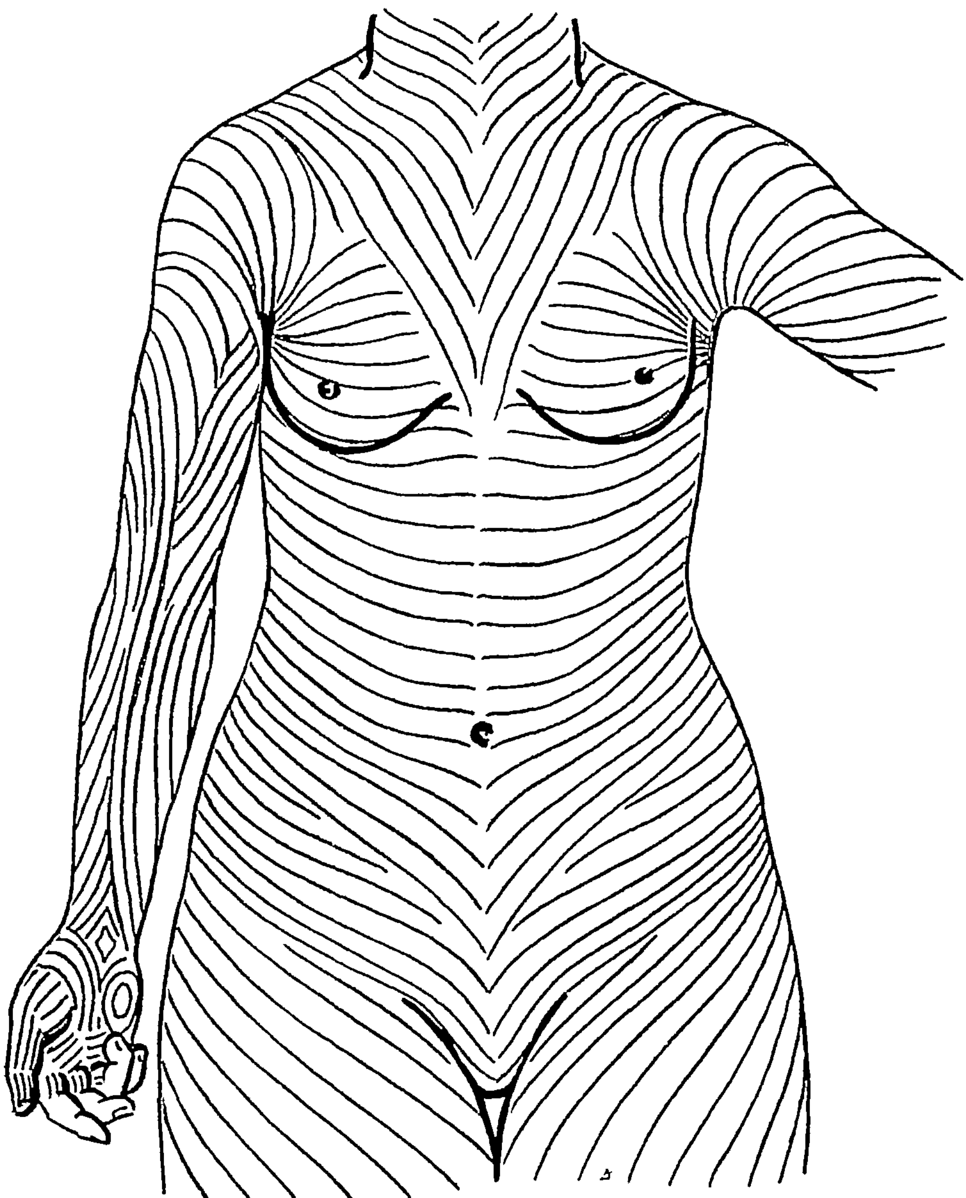

FIG 20 Diagram, showing grain of skin on anterior trunk

when the skin was stretched, and from these observations he mapped out various planes of skin tension—the so-called Langer's lines Kocher (50) of Berne, however, was the first to emphasize their surgical significance

Incisions made along these *cleavage lines* afford good exposure and at the same time effect the least impairment of the functional strength of the tissues They permit the incised wound edges to fall naturally into the most advantageous position for healing, thus placing the wound under minimal tension and reducing the stress on the

sutures Conversely, incisions made across these lines destroy the strength of the tissues, put maximum stress upon the suture line, and, since the amount of cicatricial tissue formation is determined by the burden placed upon the tissues the scar will be more pronounced and have a greater tendency to become depressed, elevated, or stretched. It is frequently possible to cut the skin along the lines of tension, even though the underlying pathologic lesion apparently contraindicates such a course.

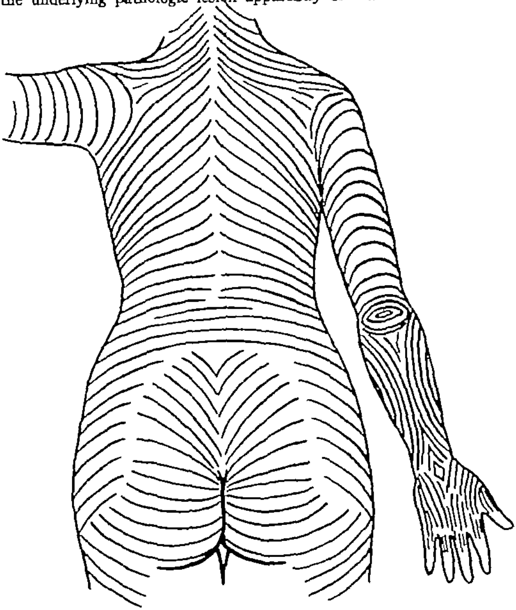

FIG 21 Diagram, showing grain of skin on posterior trunk

After the skin incision has been made to correspond with the lines of tension, the margins are retracted and the subcutaneous structures divided in any direction desired.

As has been previously said, it is essential that the knife used for the incision be sharp A dull knife inflicts unnecessary trauma, bruises and lacerates the wound margins, interferes with the nicety of manipulation, and is actually dangerous, especially when used in the vicinity of important structures, inasmuch as its stroke cannot be gauged with accuracy Greater efficiency will be possible if a fulcrum is obtained by bracing the fingers at some convenient point adjacent to the line of incision, preferably on bone, since soft tissue affords an insecure and unsatisfactory base (fig 23) While

free-hand operating permits of a greater range of motion, it had best be avoided, since in the absence of a fulcrum the blade is more likely to slip

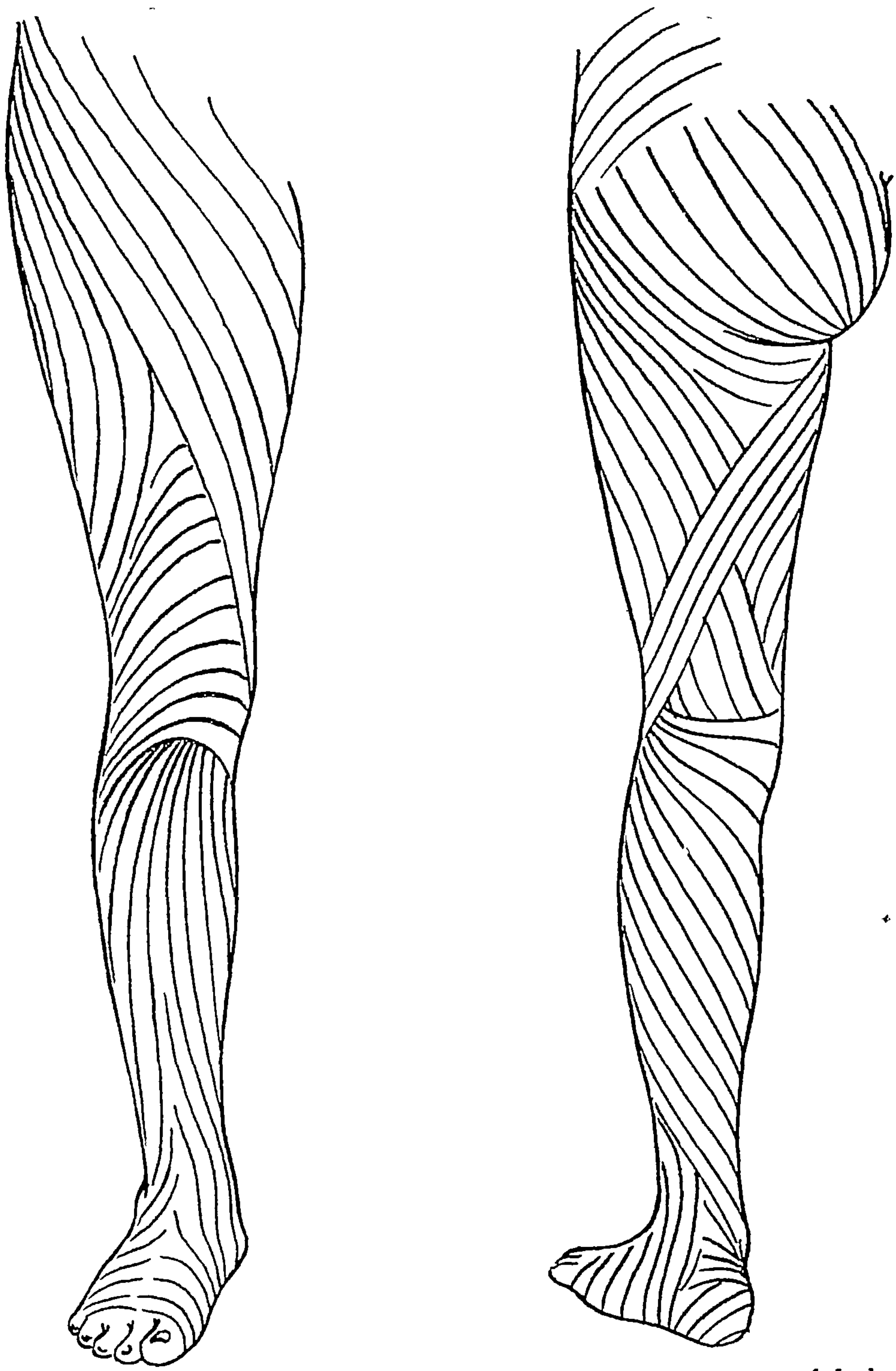

FIG 22 Diagram, showing grain of skin on anterior and posterior aspects of thigh

Throughout the operation the surgeon should maintain the erect *posture*, regardless of the manoeuvers to be executed If he cannot carry out the desired movement with his right hand, it is advisable that he effect it with the left or replace the instrument with a more convenient one, rather than alter his position

The knife should be held firmly but lightly. A tight grip not only is awkward,

but also causes tremors and restricted movements which result in an irregular lacerated wound rather than a clean incised one. The precise manner of grasping the instrument will depend partly upon the preference of the operator and partly upon the thickness and density of the tissues to be divided. There are three positions which are most frequently resorted to (fig 24) For delicate dissection necessitating short rapid movements, as in plastic operations, the knife is held like a *writing pen*, the thickest part of the handle being grasped between the thumb and the first two fingers For incisions requiring gentle but steady pressure, the *violin-bow* grasp is most practical, as it facilitates precision and nicety of manipulation If the incision requires considerable power, or if a larger instrument than a scalpel is needed, as in the case of an amputation, the best way to obtain the necessary firmness is to hold the instrument in the *table-knife* position, the upper part of the handle being fitted into the palm of the hand, and the force being controlled by means of the index finger pressing against the lower part of the handle

Division of Skin. In order to obtain the necessary exposure and facilitate subsequent closure, it is essential that the incision should be of uniform depth throughout,

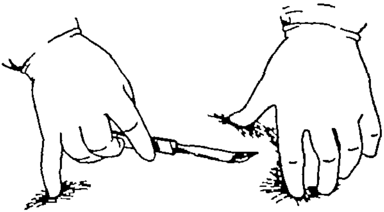

FIG 23 Method of making skin incision. Skin held taut between left index finger and thumb Incision made with right hand braced on adjacent firm surface.

without "tailing off" at the extremities of the wound in the form of a funnel, and that the edges should not be beveled or undercut. These desiderata are best assured if the skin is held taut while the incision is being made so that the knife will pass through at right angles to the surface While the left thumb and index finger stretch the skin on either side of the proposed incision, the right hand, holding the scalpel and braced on some convenient adjacent point, introduces the tip of the knife at right angles to the surface and carries it perpendicularly through the skin and fat down to the fascia The direction of the knife is then changed to form an angle of 45 degrees to the skin surface, and with a single even sweep the blade is drawn to the end of the proposed wound limit. The handle is again raised to form a right angle with the skin surface and is removed in the same relation to the surface as when first introduced The result will be a rectangular wound (fig 25)

As has been said before, the deep layers of the skin cannot be sterilized, no matter how much care is given to their preparation, it follows then, that as soon as the knife has penetrated the skin, it necessarily becomes contaminated and in its downward course is bound to force some bacteria into the wound. While these bacteria are innocuous in their normal habitat, when transplanted into raw traumatized tissues

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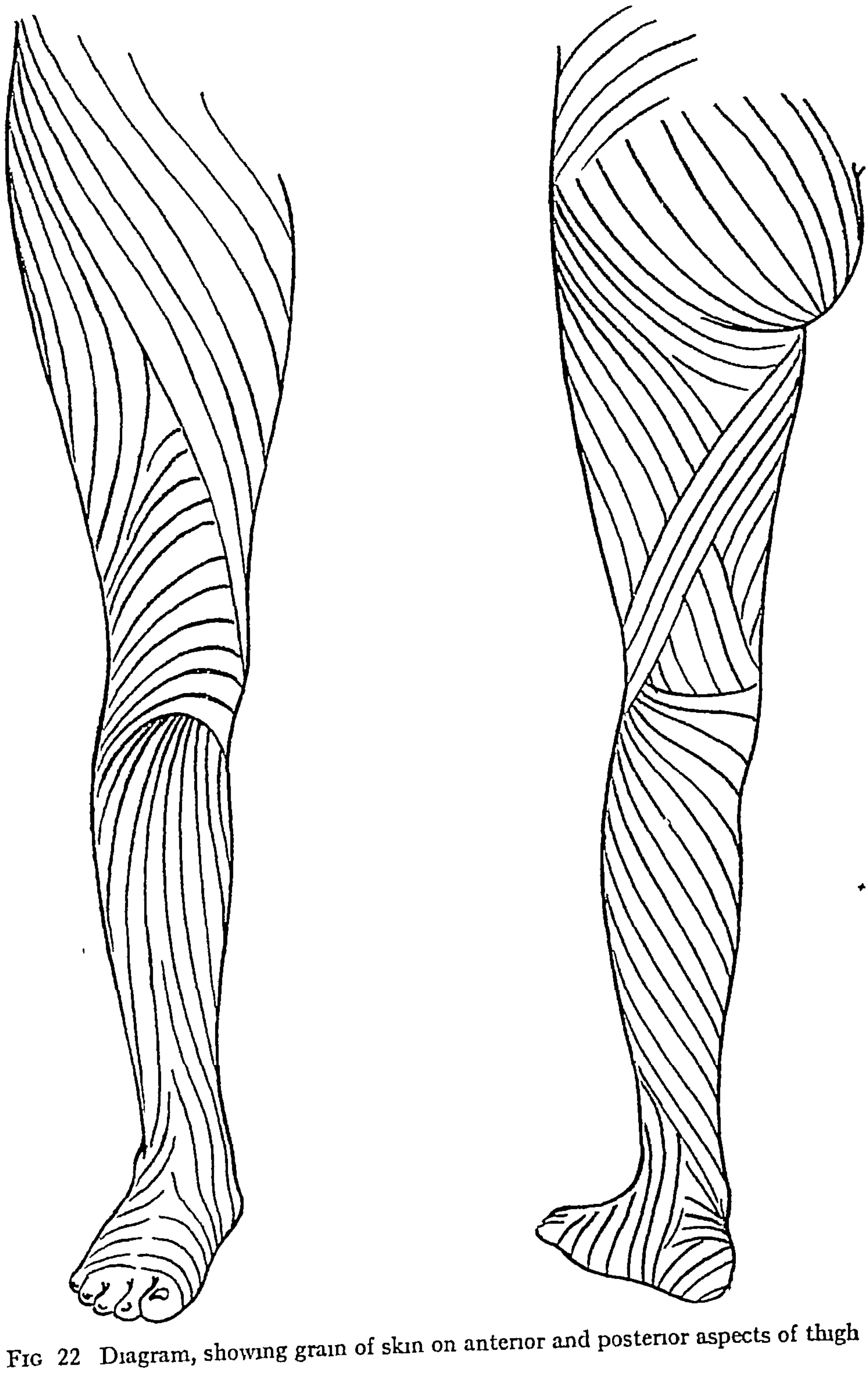

FIG 22 Diagram, showing grain of skin on anterior and posterior aspects of thigh

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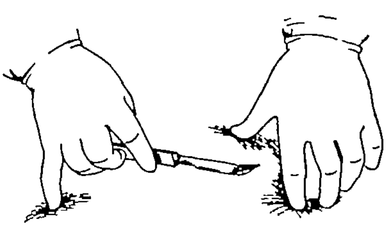

FIG. 23 Method of making skin incision. Skin held taut between left index finger and thumb Incision made with right hand braced on adjacent firm surface.

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of the proposed incision, so that the divided ends of the muscle may be subsequently identified When the severed extremities are reunited, the fascia must be included in the bite, otherwise, the sutures will cut through the soft muscle tissue

When the pathologic tissue has been exposed, it is separated from the surrounding healthy tissues by sharp dissection Blunt dissection is permissible only in areas containing important structures, as it occasions unnecessary trauma and is apt to inflict on the blood vessels tangential wounds which prevent retraction of the tunica media and thus delay spontaneous hemostasis All important structures adjacent to the pathologic tissue should be exposed, identified, and safeguarded throughout the operation Malignant tissue is removed en bloc, the excision being made to include a safe margin of healthy tissue, on the assumption that the process may have spread beyond the visibly diseased portion In cases of extensive malignant infiltration only those tissues are allowed to remain which cannot be cut away without grave anatomic or physiologic consequences All dissections are begun at the periphery, only in the final part of the dissection is the removal of the entire mass completed

Hemostasis. Throughout the operation all bleeding should be checked as soon as encountered The presence of blood in the wound obstructs the view, makes dissection dangerous, interferes with the nicety of technic, and complicates and prolongs the operation Ineffectual hemostasis also leads to the formation of postoperative hematomata which by their tension interfere with the blood supply, delay healing, and encourage infection While adequate hemostasis admits of no compromise, nevertheless it must be accomplished without the infliction of unnecessary trauma and without the addition of an excess amount of foreign material Too many ligatures and too many hemostats impair the nutrition of the part and may prove as detrimental to ultimate recovery as ineffectual hemostasis Therefore, in the control of operative hemorrhage the benefits to be derived from an absolute hemostasis, in which an attempt is made to control bleeding from even the finest vessel, must be weighed against the detrimental effects arising from the prolonged handling of tissues, recourse to hemostats, and the burial of foreign material in the wound Obviously, bleeding from all large and medium-sized blood vessels must of necessity be controlled, but as regards the smaller vessels in which spontaneous hemostasis is likely, the decision will lie between the use of multiple hemostats or ligature on the one hand, and non-interference with the vessel on the other, dependence for the control of hemorrhage being placed on spontaneous hemostasis and the approximation of the wound margins

Capillary hemorrhage is characterized by a steady oozing which usually stops spontaneously, owing to the retraction and coiling up of the intima within the lumina of the vessels The extravasated blood is removed either by means of a suction apparatus or by a gentle mopping with dry gauze The sponge should be applied with a quick, firm, decisive pressure Wiping should be avoided, not only because it is ineffectual, but also because the friction of the gauze traumatizes the tissues The bleeding vessels may be touched with an electrocoagulating point at a dull red heat, if the cautery is at bright red or white heat, it will cut through like a knife and defeat its purpose While this method speedily and effectually checks hemorrhage from small vessels, it has the objectionable feature of leaving carbonized tissue in the wound as a foreign body to be eliminated When the oozing is profuse, an excessive loss of blood may be prevented if the wound is packed with a compress wrung out of hot

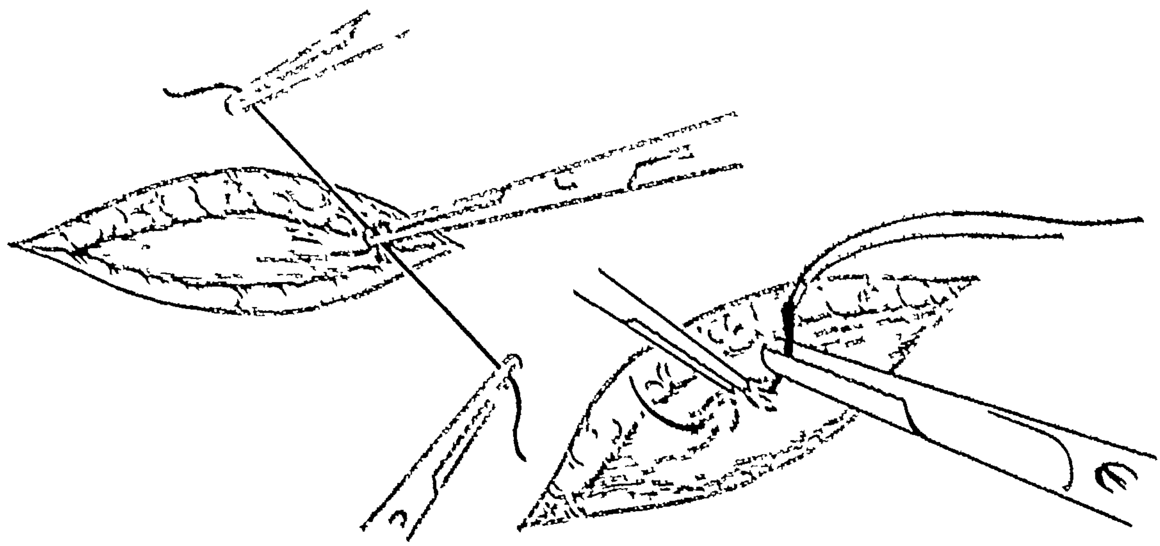
saline solution The pressure should be maintained long enough for clots to form in the lumina of the vessels—usually about 5 minutes—after which time the compress is gradually peeled off The few bleeding points remaining are caught with pointed hemostats and ligated. Capillary hemorrhage can frequently be controlled by an irrigation of the wound with saline solution at a temperature of 120° F The use of vasoconstrictors, such as epinephrin, had best be eschewed. While these drugs succeed temporarily in producing a local constriction and a cessation of hemorrhage, the subsequent vasoparesis predisposes to postoperative bleeding

Hemorrhage from parenchymatous surfaces can often be checked by the application to the bleeding part of bits of muscle, fat, or fascia which supply the thromboplastin necessary for clotting Hemorrhage from bone marrow can be controlled by pressing Horsley's bone wax (carbolic acid, 1 part, olive oil, 2 parts, white wax, 7 parts) into the defect or the margins of the bone wound may be crushed and hot compresses applied The passing of a ligature around a mass of tissue for the purpose of controlling hemorrhage is ordinarily to be condemned, but when all other measures have failed and the loss of an excessive quantity of blood is imminent, this expedient may serve as a last resort. In such cases the pressure should be sufficient merely to control the bleeding without strangulation of the tissues.

Arterial hemorrhage is characterized by bright red blood spurting from the cut vessel and *venous hemorrhage* by a more or less steady stream of dark red blood issuing from the wound. The control of such hemorrhage takes precedence over all other considerations. If the bleeding point can be defined, the vessel is caught along its long axis with a fine-pointed hemostat, care being taken that only the vessel is incorporated in the bite, since the smaller the amount of contiguous tissue included, the less the subsequent sloughing If the vessel cannot be located, dry gauze pressed against the bleeding part and quickly removed will serve to disclose it. In case of copious hemorrhage the vessel is grasped with the fingers until the field can be cleared. The fingers are then slowly removed, and the bleeding point located and caught with a hemostat This procedure will minimize the loss of blood and at the same time will do away with the tissue damage occasioned by the tentative blind application of hemostats in a blood flooded field.

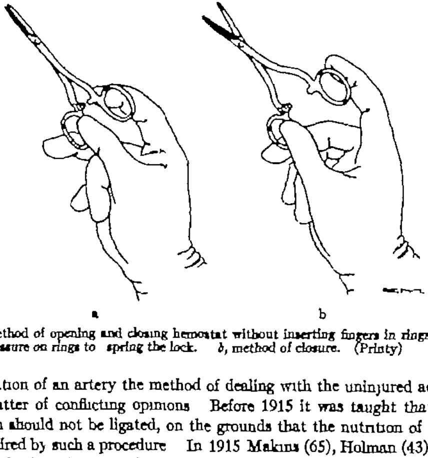
In the ligation of vessels both proximal and distal ends should be tied, otherwise hemorrhage may occur through the distal end when collateral circulation becomes established. The ligature is passed around the clamped vessel, the handle of the hemostat is depressed by the assistant to elevate the point, and a simple knot is tied just behind the point of the clamp at right angles to the line of the artery The knot is then tightened deliberately and slowly, the tips of the two index fingers meeting on the artery and pressing the knot down while it is being tied (fig 27c) The hemostat is thereupon detached in the following manner The thumb and forefinger are placed in the rings and the pressure is tightened sufficiently for the release of the lock, or the pressure is applied to the rims of the rings and the lock opened by 'springing' the clamp (fig 28) The second tie is then completed to form a square knot and the ends are cut just enough ligature material being left to prevent any slipping of the knot. After this, all non viable tissue above the knot is excised In the case of small vessels a single square knot is sufficient, but for larger ones two ligatures are passed around the vessel each suture tied in a single knot, and the two pairs of ends tied together in

the form of a reef knot (p. 80). Some surgeons prefer to clamp the vessels and postpone ligation until the hemostats become so numerous as to obstruct the field, at which time the ligatures are applied and the hemostats removed, this procedure being started at a definite point and continued clockwise around the wound.



a b

wound. The force to be expended on the tying will also depend upon the size and thickness of the vessel wall. The ligature should be tied tightly enough to close the lumen of the vessel and perhaps rupture its inner coat, but it should not be so taut as to cut through both the inner and middle coats, since this would predispose to secondary hemorrhage. In any case the force required is seldom greater than 5 pounds, even for a good-sized blood vessel. The choice of the material to be used lies between fine silk and catgut. For aseptic wounds silk is preferable, as it is non irritating and makes a secure and unyielding knot, but in the presence of infection the use of silk may result in persistent sinuses and local abscesses which may necessitate its subsequent removal. Therefore, if asepsis is questionable, fine catgut is more desirable despite its objectionable tendencies to stretch, become unknotted, and undergo absorption before the organization of the blood-clot has taken place. For smaller vessels size #0 to #1 plain catgut is chosen, and for larger vessels size #1 chromic catgut.



a b

FIG. 28 Method of opening and closing hemostat without inserting fingers in rings *a* hemostat released by pressure on rings to spring the lock. *b*, method of closure. (Printy)

In the ligation of an artery the method of dealing with the uninjured accompanying vein is a matter of conflicting opinions Before 1915 it was taught that the accompanying vein should not be ligated, on the grounds that the nutrition of the part was further impaired by such a procedure In 1915 Makins (65), Holman (43) and Martin pointed out the fact that occlusion of both vessels is less likely to be followed by impaired nutrition than ligation of the artery alone These investigators based their arguments on the assumption that if the vein is not ligated, the diminished quantity of blood carried by the ligated artery is afforded too easy an outlet and is drained away before the collateral circulation becomes sufficient to nourish the tissues distal to the ligature. They accordingly suggested ligation of the accompanying vein for the purpose of striking a balance between the enfeebled arterial circulation and the accelerated venous return. Brooks (8) believes that the favorable effect of a simultaneous ligation of the accompanying vein is attributable to a raised intravascular pressure which serves to keep the capillaries open in areas in which they would otherwise collapse Leriche (58) believes that the benefits of concomitant venous ligation

are due to the reflex vasodilatory action of the sympathetic nerve fibers. Generally speaking, pulsation in the distal stump following the division or an artery indicates an efficient collateral circulation, and in such cases the accompanying vein need not be ligated If, however, pulsation is absent, the collateral circulation is probably deficient, and under these circumstances the artery and vein should be ligated simultaneously

In the case of a lacerated blood vessel wherein the collateral circulation would not be sufficient to sustain the nutrition of the part if the artery were ligated, it may be feasible to repair the wound by an immediate lateral or end-to-end suture (figs 163–165) Suturing will not be successful, however, if the vessel is contused or lacerated, if more than 1 8 cm of its length has been damaged, or if infection is present The chief hazards in the suturing of blood vessels are occlusion of the lumen by thrombus formation and aneurysmal dilatation at the site of the cicatrix These risks can be somewhat diminished by recourse to a simple atraumatic technic, by a prevention of the drying out of the endothelial cells of the intima, and by a limitation of the amount of foreign substance introduced into the lumen The details of the technic are given on page 294. Briefly, suturing is done with the finest silk coated with sterilized vaselin and mounted on fine, straight round needles The sutures should be so placed as to effect a water-tight closure without encroachment on the caliber of the vessel or on the intima The injured segment of the vessel is exposed for nearly an inch beyond each end of the part to be sutured, in order to allow room for the application of suitable clamps for the control of bleeding during the passing of the suture After the injured segment has been isolated, the blood within it is removed by irrigation with saline solution, and the suturing proceeded with After completion of the suture, the clamps are removed, and, if oozing takes place, 1 or 2 supplementary Lembert sutures are introduced, the outer part of the vessel thus being folded over the line of suture If the wound exceeds $\frac{2}{3}$ of the circumference of the vessel, it is advisable to complete the division of the vessel, refreshen the edges, and perform an end-to-end anastomosis (p 295) If direct anastomosis would involve the danger of too great tension, the question arises as to the advisability of a vein transplant or the introduction of a Tuffier tube for the maintenance of the nutrition of the part until a collateral circulation has developed But these procedures are hazardous, and the results are for the most part unsatisfactory

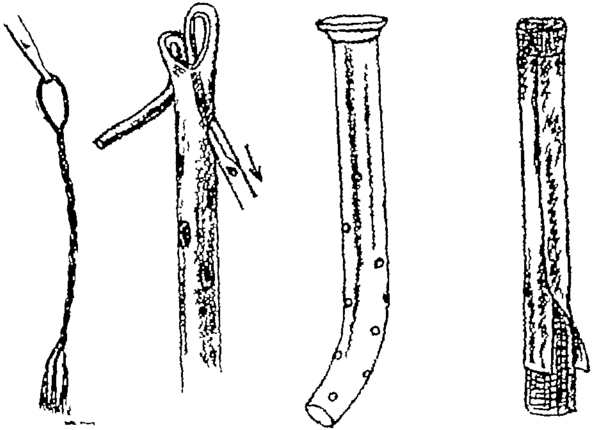
Closure of Operative Wound

Drainage. Before the closure of the wound drainage must be considered Generally speaking, drainage is to be avoided in aseptic wounds, since drains act as foreign bodies, form tracks for infection, delay healing, and increase the extent of the ultimate scar There are, however, circumstances in which drainage of aseptic wounds is called for—for instance: (1) In the presence of an unavoidable dead space into which oozing and hemorrhage is anticipated, especially when the space is so situated that the force of gravitation can be of no assistance, or when the cavity cannot be obliterated by external pressure, as, for example, following the removal of a tumor from the neck, or where sutures cannot be placed far enough apart to permit of natural drainage, as in instances where an especially fine scar is desired Under such conditions failure to provide drainage will cause the cavity to become filled with discharges which may serve as culture media for bacteria (2) When hemostasis is questionable In such

cases, however, drainage should not be instituted as an excuse for a perfunctory control of hemorrhage. Recourse to drainage merely for the removal of blood anticipated from an insecurely tied vessel is an admission of weakness in technic.

In septic wounds drainage is imperative, as it prevents absorption of bacterial products under tension and assists the escape of pus and inflammatory products which would otherwise cause local irritation, separate the walls of the wound, and interfere with healing

In wounds which are potentially infected, such as those inflicted on inflamed or edematous tissue, those in which all diseased tissue has not been removed, or those



a b c d

FIG 29 Various types of drains *a* loosely braided strands of suture material serving as capillary drain. Used for temporary drainage of small wounds where slight oozing is expected. *b* self retaining rubber drain. Holes cut along surface end split into 2 segments and drawn through holes below as precaution against loss Designed to assist gravity drainage. *c* glass drain with shoulder to prevent slipping Also used to assist gravity drainage *d* cigarette drain consisting of gauze roll enclosed in sheet of rubber Serves as capillary drain.

into which considerable foreign material in the form of ligatures has unavoidably been admitted, the advisability of drainage is debatable. Here the choice lies between closure *with* drainage, with its attendant scarring and lowering of local resistance, and closure *without* drainage, in the hope that the inherent bactericidal properties of the tissues will prevent infection The decision is difficult, and no definite rules can be laid down. Each case must be decided on its merits.

Drains act either in a capillary capacity or as aids to gravity Capillary drains are made of gauze, gutta-percha, pieces of rubber dam, candlestick wicking, pipe cleaners, or twisted or loosely braided strands of catgut, silkworm-gut, or horsehair

(fig 29) They are used principally for temporary drainage of small wounds where slight oozing is expected Drains designed to assist gravity are tubular in form and made of India rubber, glass, celluloid, or metal They are employed in larger wounds and in cases where drainage is required over a more or less prolonged period They must be smooth to permit of ready removal, capable of easy sterilization, and not so brittle as to break off in the tissues or so rigid as to cause undue pressure on adjacent blood vessels and nerves Generally speaking, the smallest drain capable of serving the

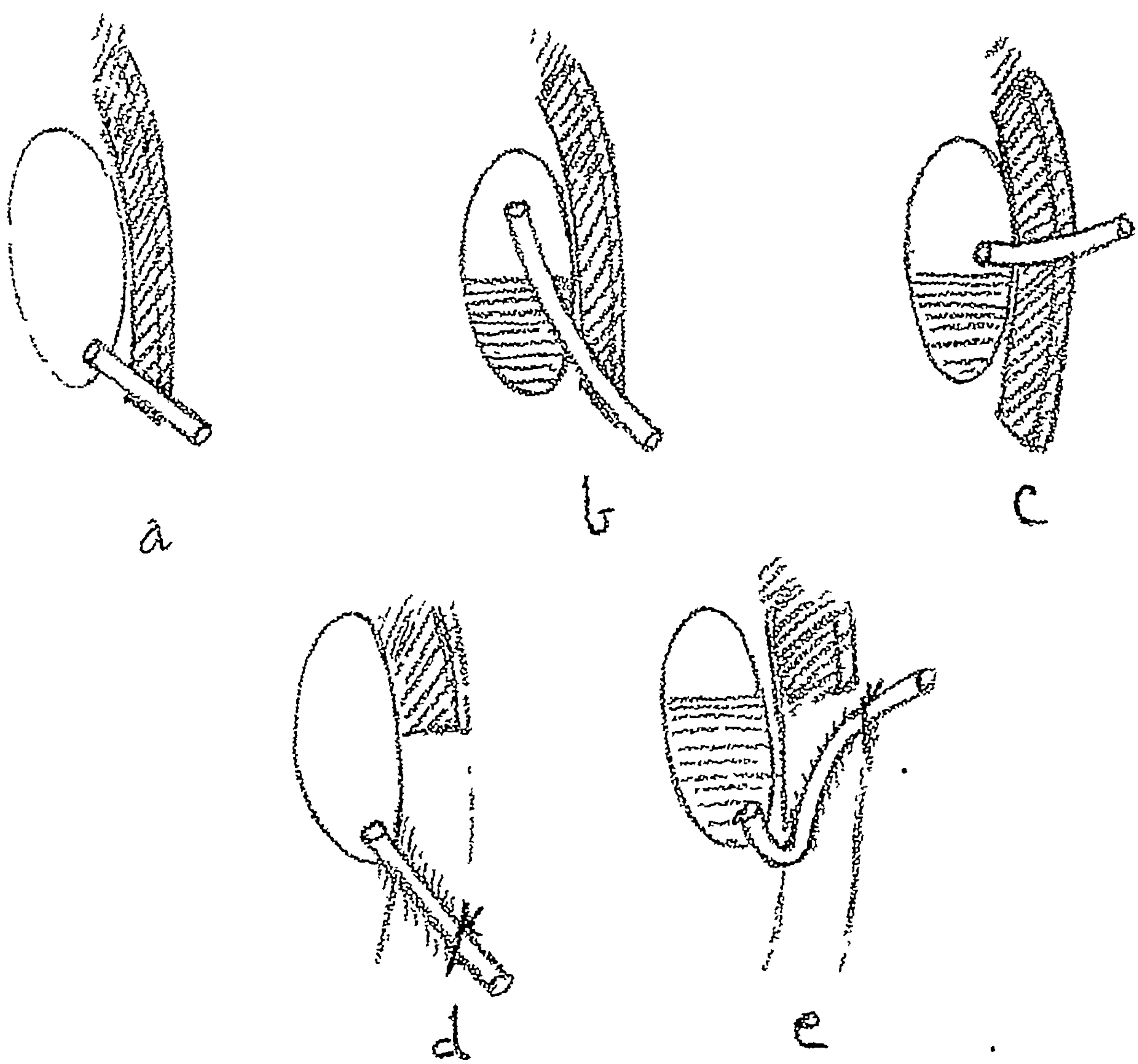


FIG 30 Gravity drainage *a*, satisfactory dependent drainage *b–c*, poor drainage *d*, satisfactory counter-drainage *e*, poor counter-drainage (Roux)

desired purpose should be chosen, and inasmuch as the escape of fluid is assisted by gravity, the drain should be inserted into the most dependent part of the wound (fig 30) The wound is then closed, 2 or 3 sutures being left untied in the vicinity of the drain, to be completed upon its removal. When the wound does not lend itself naturally to gravity drainage, it is sometimes advisable to close it and secure drainage through an independent counter-opening at a more advantageous location (fig 31) When drainage is resorted to, the surrounding skin should be well lubricated as a protection against irritation from the secretions, and the dressings should be so arranged as not

to obstruct the flow of discharges Drains should be removed promptly after they have accomplished their purpose. In aseptic wounds they can usually be dispensed with in 24 to 48 hours, in septic wounds they are left in for several days, the duration being governed by the severity of the infection.

Gauze drains are employed in widths varying from 1 to 7 cm, and are used plain or impregnated with an antiseptic such as iodoform or boric acid. The chief objection to this material for purposes of drainage is that its meshes soon tend to become filled with coagulated fluid and plug the wound, often causing it to lock up the secretions in place of releasing them Furthermore, gauze is apt to adhere to the wound, and its removal not only causes pain but also damages the newly formed granulations and

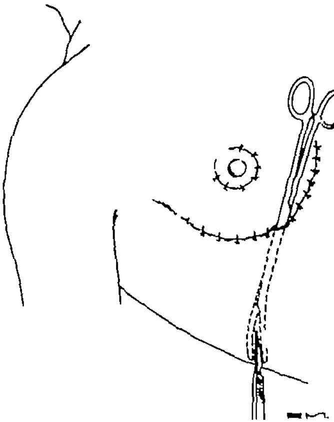


FIG 31 Counter-drainage—employed where wound does not lend itself naturally to gravity drainage. Dressing forceps introduced into original incision forced through tissues, and points pushed against skin at site of proposed counter-opening points opened slightly and skin between cut down upon.

opens up lymph spaces for the spread of bacteria. Consequently, when gauze is used, it should be impregnated with a lubricant, such as vaselin, or covered with some material like gutta percha, cello-silk, or cellophane in the form of a cigarette drain. In any case, it should be packed loosely and changed frequently

Rubber dam although it has less capillarity, is superior to gauze as a drain since it is less irritating and does not adhere to the newly formed granulation tissue As a precaution against its loss in the depth of the wound, it should be anchored by means of a safety pin attached to its exposed end.

Gutta percha drains owing to the difficulty of their manipulation and the impossibility of their sterilization with heat, have been largely supplanted by rubber sheaths (Penrose tubing) which can be sterilized by boiling for 15 minutes

Rubber drainage tubes come in various sizes, the average diameter ranging from 0 6 to 1 25 cm Their walls should be firm enough to resist compression and kinking, but not so rigid as to cause pressure on surrounding blood vessels and nerves, and the canal should be sufficiently large to permit of an unobstructed flow of the discharges These tubes have the advantages over other materials that they can be partially removed by shortening at each change of dressing and may be used as a means of irrigating the wound if necessary Before the insertion of the tube, small holes are cut at intervals along the side to assist the process of drainage and the end is cut obliquely to facilitate passage of the tube into the wound cavity As a precaution against loss in the wound, the end of the tube may be split longitudinally into two segments and each segment drawn through a slit in the tube just below it (fig 29b), or after the introduction of the drain a safety pin may be passed through the exposed part and at right angles to it In either case it is well to insert a pad of gauze beneath the exposed end to protect the skin from pressure Silk threads passed through the drain, their ends fastened to the skin with adhesive plaster, will serve the same purpose In order to prevent buckling of the drain during its introduction and to insure its reaching

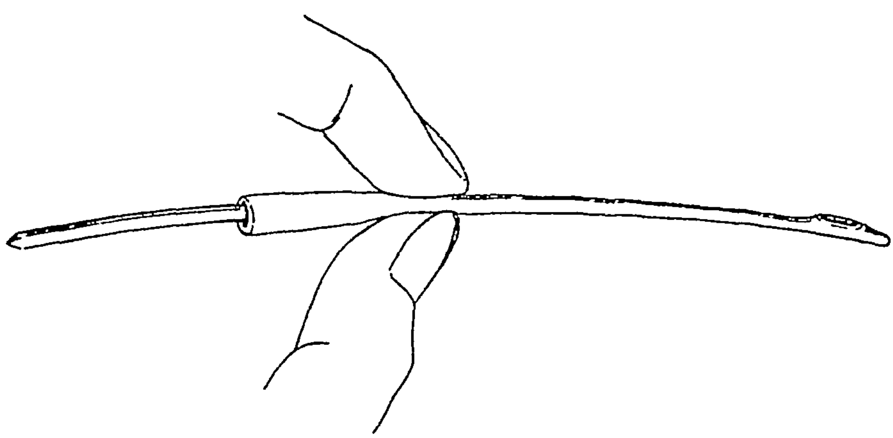


FIG 32 Method of introducing rubber drainage tube Tube stretched on sound to prevent buckling and insure its reaching bottom of cavity

the bottom of the cavity, it is stretched on a sound (fig 32), and inserted into the wound to the desired depth, after which the sound is withdrawn and the drain left in place Rubber drains are sterilized by boiling for 20 minutes and are stored in sterile jars in lengths of 15 to 20 cm. until ready for use

Glass drainage tubes come in various sizes and are provided with shoulders to prevent their slipping into the wound It is frequently of advantage to insert a strip of gauze into the tube as a supplementary capillary drain The greatest disadvantages of glass tubes are their fragility, and their rigidity which may damage the surrounding structures by pressure

Cigarette Drains In order to obtain the benefits of the capillarity inherent in gauze and at the same time permit of its easy removal, rolls of wicking or gauze may be encased in a sheet of rubber tissue cigarette fashion, or the same effect may be produced by drawing a strip of gauze through a rubber tube Drainage will be facilitated if the sides of the rubber tissue are perforated and the gauze is made to project beyond the rubber at each end

Special drains will be described in the appropriate sections

Approximation of Wound. The final step in every operation is the mechanical approximation of the divided tissues to obliterate dead spaces, protect against infection, serve as a guide for permanent organic union, and minimize the ultimate scar If there has been no loss of tissue, closure is effected by direct approximation of the walls of the wound. When the tissues do not permit of direct closure without tension, approximation may still be attained by undermining the wound margins by making one or more incisions lateral and parallel to the wound, or by advancing the surrounding tissues over the raw area by one of the methods depicted in Figures 138–145 But if the loss has been extensive, closure can be effected only by the addition of new tissue in the form of a graft or flap (Chapter II)

The divided tissues must be made to resume their former relationships Closure of the skin wound is a minor problem. A more difficult matter and one of great importance to the ultimate outcome is the approximation of the walls of the large raw area beneath. If the skin is approximated and the deep tissues are ignored, exudates

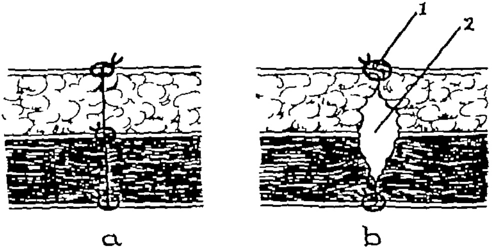


FIG 33 Closure of deep wound. *a* correct closure. Each of divided structures closed individually in tiers like tissue to like tissue, beginning in depth of wound and continuing upward. *b* incorrect method of approximation. *1* skin overlapped. *2* dead space left for accumulation of exudates and hematomata which invite infection delay healing and predispose to stretching of scar (Cole and Elman's Surgery)

and hematomata will accumulate in the remaining dead space (fig 33) and invite infection, healing will be delayed, and the surface scar, regardless of the carefulness with which the skin wound may have been closed, will stretch because of insufficient support. If the incision is short and shallow, it may be closed with several sutures, each being made to include all layers of the wound (fig 34-2) If the wound is deep or extensive, however each of the divided structures must be closed individually in tiers, like tissue to like tissue, beginning in the depth of the wound and continuing upward (fig 33) Especially important is the approximation of the divided fascia and aponeurosis since fat and muscle when sutured are too fragile to be depended upon to hold the wound margins in apposition. Moreover, fascia is the main support of the skin, and if it is not carefully coapted, the overlying skin scar is likely to stretch In order to minimize the surface scar, the skin edges should be brought together without vertical or horizontal deviation and without inversion This process can be facilitated by gentle traction made at each angle of the wound by means of blunt dural hooks or traction sutures With the wound edges thus reduced to a straight simple line,

it will be possible to include in each bite of the needle an equal amount of symmetrically placed tissue Figure 34-1 shows the direction of the sutures in irregular wounds

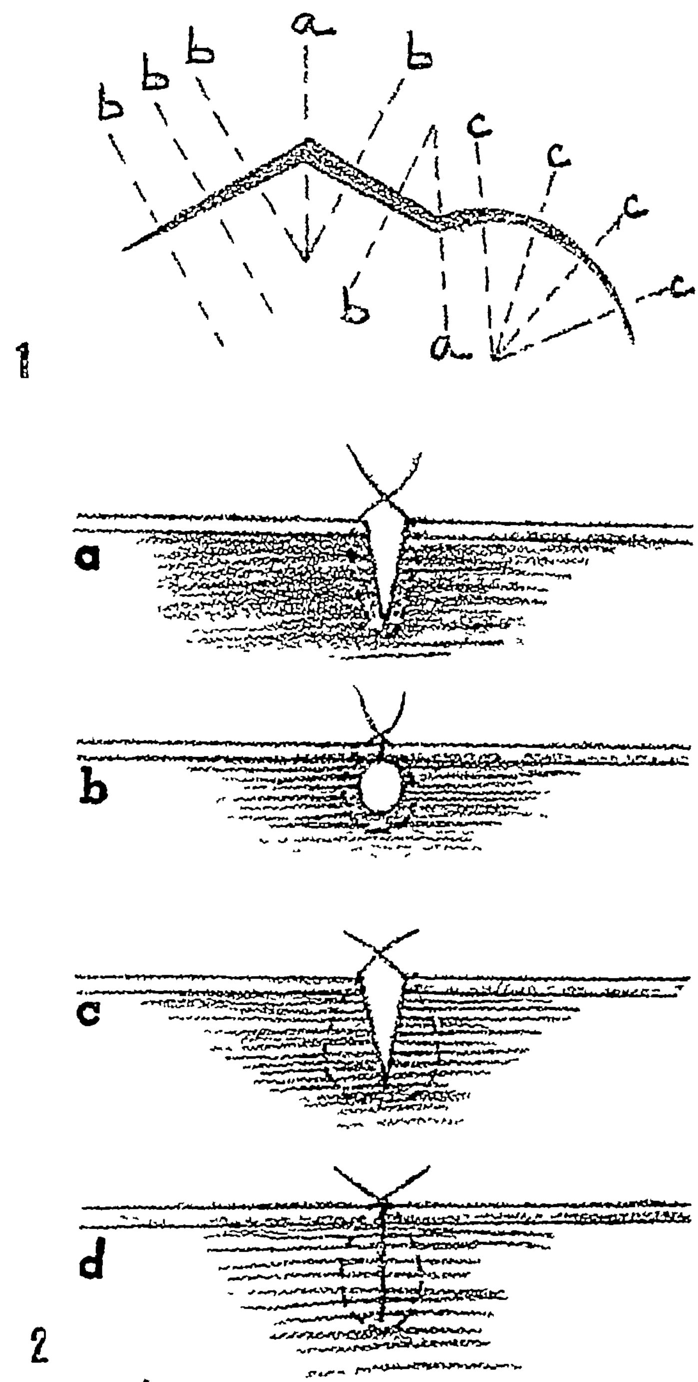


Fig 34 Method of suturing *1*, direction of sutures in irregular wound *a*, at angles, suture is made to bisect angle exactly *b*, limbs of angle sutured at right angles to wound margins *c*, in curved wound, shaft of needle takes direction represented by the radius of a circle of which wound margin forms the circumference (van Schaick) *2*, sectional view *a*, suture introduced parallel to wound surface results in *b*, formation of dead space under skin from purse-string action of suture *c*, correct manner of passing suture It is carried well into tissues on each side *d*, when suture is tightened, whole depth of wound is brought together (Johnson)

The suture is passed in the following manner· If a curved needle is to be used, it is passed by means of a needle holder, the needle being grasped at the junction of its upper and middle thirds as a precaution against breakage With a fine dural

hook held in the left hand, the subcutaneous tissue along the edge of the wound distal to the operator is picked up and gently everted, care being taken not to touch the skin Then with the needle holder held in the right hand in the position of utmost

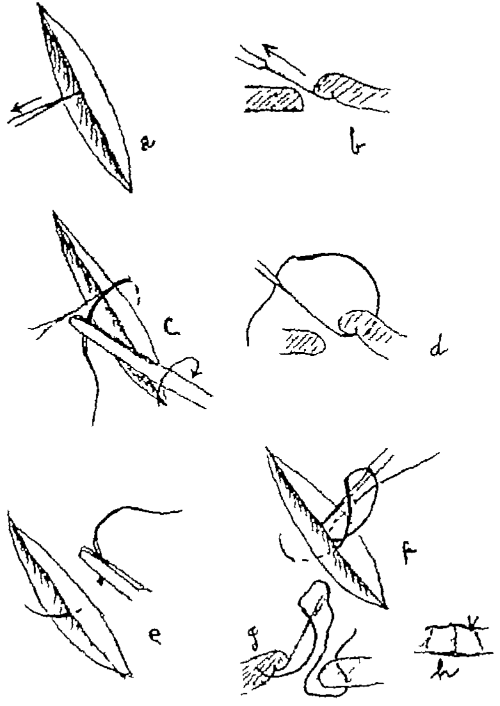


FIG 35 Method of passing interrupted suture *a* distal margin everted with dural hook, care being taken not to touch skin. *b* sectional view *c* needle engaged in skin 0.5 cm. from wound edge and, by supination of wrist, carried through tissues. *d* sectional view *e*, point of needle exposed in wound. *f* proximal margin raised with dural hook, and needle passed from within outward, emerging on skin of proximal side at equal distance from wound. *g* sectional view *h* suture tied. (Gillies)

pronation, the needle is engaged in the skin of the elevated wound margin at a point about 0.5 cm. from the wound edge and by means of a supination of the wrist it is made to pass through the tissues until the point is fully exposed in the wound The

margin nearest the operator is then raised in a similar manner and the needle passed through the tissues from within outward, emerging on the skin of the proximal side at an equal distance from the wound edge The needle is then released and the point is grasped with the holder and withdrawn If the wound margins are widely separated or the tissues dense, the course of the needle should be interrupted by first drawing it completely through the distal lip of the wound, and then taking a second bite through the proximal lip (fig 35). If a straight needle is used, it is most conveniently passed with the fingers and the direction of its course is opposite to that of the curved needle—i e, from the proximal to the distal wound margin

Whether or not each individual suture is to be tied as passed or whether all sutures are to be tied at one time is a matter of personal preference Some surgeons are of the opinion that if all the sutures are passed before they are tied, the tension will be more evenly distributed and more accurate approximation will be possible. Thompson (95) passes a series of straight threaded needles through both edges of the wound at proper intervals along its entire length but does not pull them through until all

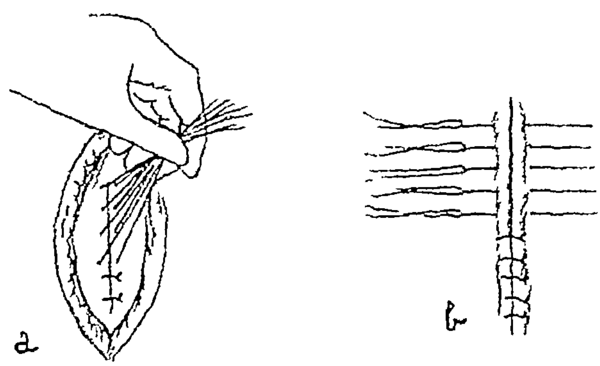


FIG 36 Method of suturing wound *a*, all sutures passed through fascia before tying, to distribute tension evenly *b*, skin margins splinted by needles passed through both edges of wound along its entire length When all have been passed, each needle is drawn through and suture tied (Thompson)

have been placed (fig 36). This procedure he believes splints the incision, permits of a more accurate approximation of the margins, and causes less tension

In wound closure by suture the ultimate nature of the union—assuming an aseptic and an atraumatic technic, and eliminating the personal factor of the patient's healing power—will depend upon (1) the suture material employed, (2) the tension under which the sutures are tied, (3) the distance between them, and (4) the method of suturing and tying

Choice of Suture Material The choice of suture material is governed by the character of the tissues to be approximated, the load to be placed upon them, and the location of the wound As previously stated, the suture should be of the smoothest, finest, and least irritating material capable of accomplishing the desired effect A fine strand inflicts the least amount of tissue damage by permitting the use of a fine needle and preventing the danger of tying under tension There is nothing to be gained by the use of a suture of greater strength than the structure which it approximates For the coaptation of deep tissues where asepsis is absolute, fine silk is employed In all other cases catgut is used For fascia, #1 20-day chromic catgut, for muscle, #1 plain catgut, for tendons, #0 or #1 chromic catgut, and for subcutaneous tissues, #00 or #000 plain catgut For purposes of skin approximation horsehair or fine

waxed silk or ophthalmic gut on an atraumatic half-curved needle will effect the least damage and result in the finest scar For relaxation sutures silkworm-gut is most suitable. In areas which are naturally moist, such as those around the mouth, wire sutures are frequently of advantage, as they are non-absorbent and do not harbor bacteria.

Tension In the tying of sutures, tension should be reduced to a minimum Sutures tied under too great tension will either obstruct the circulation and lead to excessive tissue reaction and necrosis, or will cut through On the other hand, if they are tied too loosely, union will be faulty, dead spaces will remain and the scar will be conspicuous. Sutures, when tied, should do no more than allow the tissues to fall into easy apposition and serve as stays against muscular action. Any wrinkling or discoloration caused by a suture would warrant its immediate removal. If the wound edges become blue there is likelihood of venous obstruction, if pink, of lymphatic constriction, and if blanched, of interference with the arterial supply

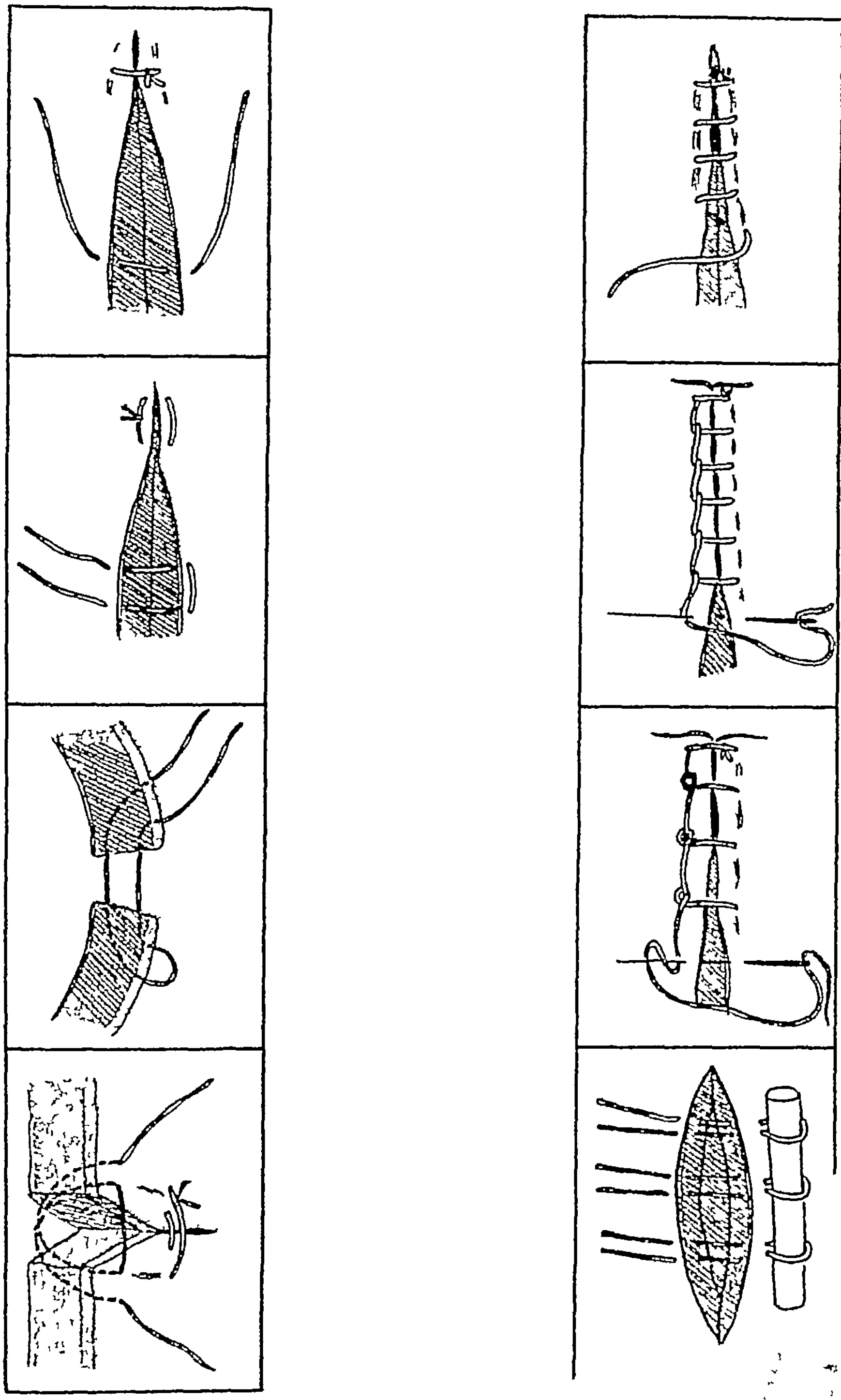
Distance between Sutures The proper distance between the sutures and the amount of tissue to be incorporated in each bite will depend upon the depth of the wound, the likelihood of a discharge, the character of the tissues, and the degree of tension. When sutures are placed too close together, they tend to strangulate the tissues, add to the amount of foreign material in the wound, and interfere with the escape of serum or inflammatory exudate Conversely, if placed too far apart, approximation will be faulty, the skin edges will tend to turn inward, and dead spaces will remain to favor the collection of exudates When the appearance of the subsequent scar is a special consideration and the wound is aseptic, the sutures should be passed at a distance of 3 to 4 mm. from one another, but if the wound is unclean, or if subsequent discharge or hemorrhage is imminent, they should be farther apart to allow for drainage Approximation sutures should be passed as close to the edge of the wound as possible. However, they should be far enough away to permit of a good hold on the tissues, otherwise, they are apt to cut through, especially if the suture material is fine. Relaxation sutures should be spaced 1 to 2 cm apart and at such a distance from the wound edge that when tied they will absorb the required amount of tension.

Methods of Suturing (fig 37) There are many methods of suturing, and the choice will depend on the individual circumstances. For convenience sutures are classified according to their function and manner of insertion into (1) approximation sutures, which are introduced at the margin of the wound and may be (a) interrupted, or (b) continuous, and (2) relaxation sutures which are placed at a distance from the wound margin and serve to transfer tension from the wound.

The interrupted suture is one in which each stitch is self-contained and tied independently It may consist of a simple loop (buttonhole), or it may be of the mattress type, in which both ends of the suture project on the same side of the wound. Although the interrupted suture consumes more time, it is superior to the continuous type in that a break at any one point will not jeopardize the entire line. Another advantage is that, if necessary, one or two sutures may be removed without need of opening the entire wound.

The mattress suture is usually passed as an interrupted suture, but may be continuous. The first step of the former type corresponds to the passing of a simple interrupted suture The needle is then reinserted through the skin on the same

side of the wound at some distance from its point of exit, the loop thus formed being parallel with the line of incision. It is then carried through the tissues and made to



a b

FIG 37 Various types of sutures *a*, from above downward Simple interrupt rupted mattress-suture On-end mattress-suture Loop suture (combined coaptat suture) *b*, from above downward Continuous suture, or whip stitch Continuous s (glover or buttonhole suture) Continuous double-locked stitch Bolster or quil details, see text (Foote's Surgery)

appear on the surface of the skin on the opposite lying distance from the wound edge as the point of U-sha is formed, its loop lying parallel to one edge of th e ends

on the other side. This type of suture is especially useful in friable tissues and in those which are subject to tension, as it is not so likely to tear through, although it is more apt to interfere with the circulation in the wound edges than is the simple loop suture

The interrupted on-end or vertical mattress suture (fig 38) is preferred by most surgeons for purposes of skin closure, since it effects a more accurate apposition, obliterates dead spaces, and reinforces the subcutaneous tissues, thus preventing subsequent stretching of the scar The technic is as follows A simple interrupted suture is

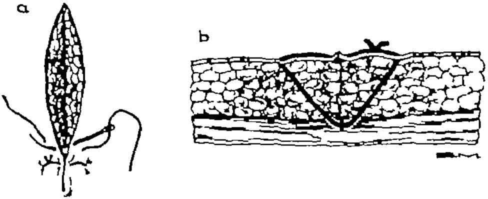


FIG 38. Method of passing McMillen's interrupted on-end mattress-suture *a* suture passed through both margins of wound Needle reversed and made to enter skin between point of emergence and wound margin and carried through tissues to opposite margin in similar manner Suture ends project on one side loop lies at right angles to wound on opposite side. *b* sectional view showing eversion of skin edges when suture is tied This suture effects accurate apposition of skin margins, obliterates dead spaces, and reinforces subcutaneous tissues (Davis)

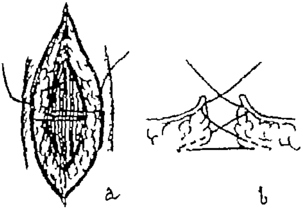
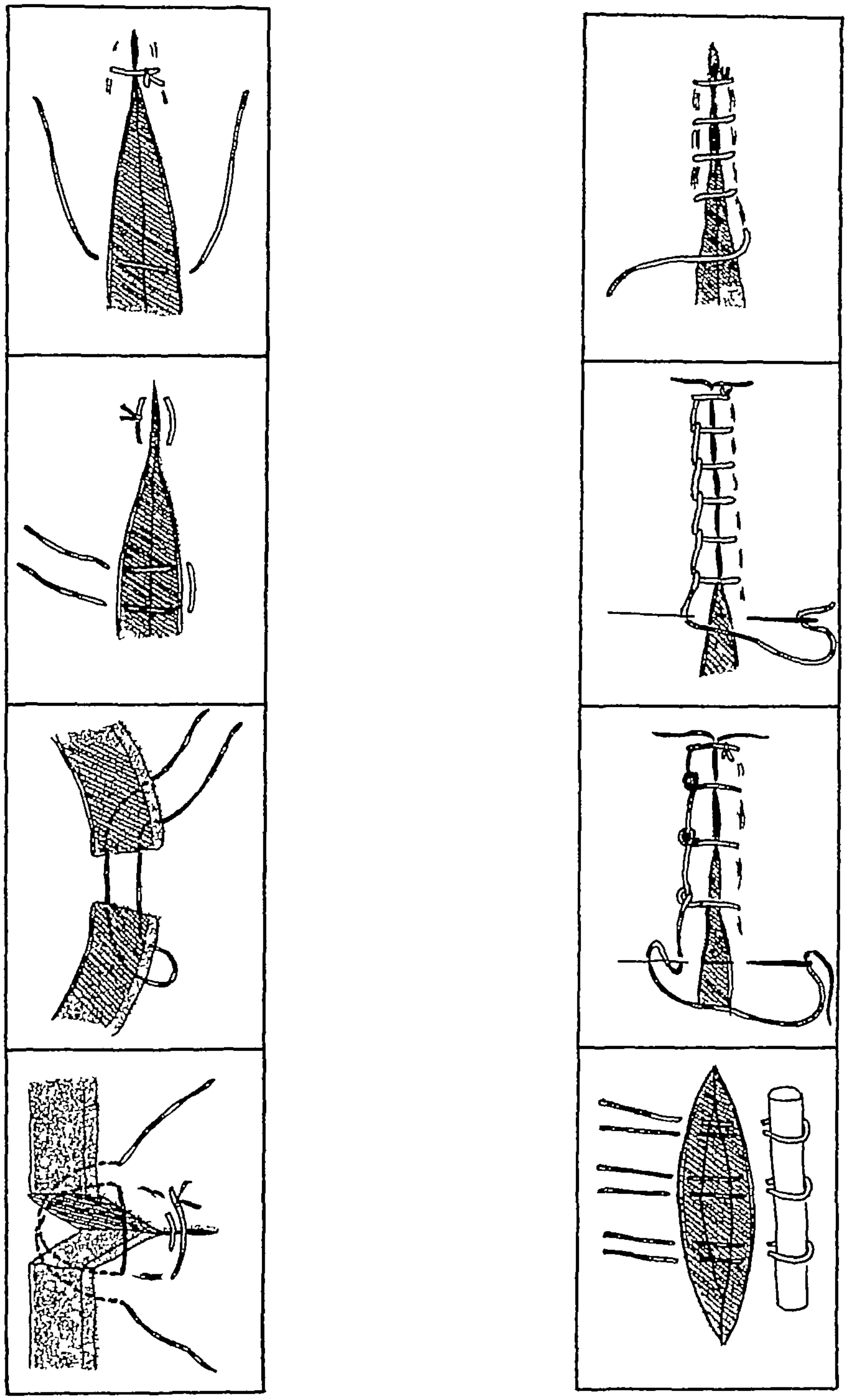


FIG 39 Near far far near suture. *a* needle passed on far side of distal wound margin, made to emerge on near side of proximal wound margin and process reversed. *b* sectional view showing coaptation and relaxation of tissues effected by suture. (Gillies)

passed, the needle entering and emerging at some distance from the edges of the wound. The direction of the needle is reversed, and it is now made to enter the skin between its original point of emergence and the wound margin. It is then carried through the tissues to issue through the opposite margin in a similar manner, both ends lying on one side the loop thus formed being at right angles to the wound. When the suture is tied, the lips are necessarily everted.

The "near far far-near suture" (fig 39) is valuable for the approximation of deep structures. The needle is passed through the subcutaneous tissues on the far side of the distal wound margin and made to emerge on the near side of the proximal wound

side of the wound at some distance from its point of exit, the loop thus formed being parallel with the line of incision It is then carried through the tissues and made to



a b

Fig 37 Various types of sutures *a*, from above downward Simple interrupted suture Interrupted mattress-suture On-end mattress-suture Loop suture (combined coaptation and relaxation suture) *b*, from above downward Continuous suture, or whip stitch Continuous single-locked stitch (glover or buttonhole suture) Continuous double-locked stitch Bolster or quilled suture For details, see text (Foote's Surgery)

appear on the surface of the skin on the opposite side, at a point lying at a similar distance from the wound edge as the point of entrance Thus a U-shaped suture is formed, its loop lying parallel to one edge of the wound and its free ends emerging

on the other side. This type of suture is especially useful in friable tissues and in those which are subject to tension, as it is not so likely to tear through, although it is more apt to interfere with the circulation in the wound edges than is the simple loop suture

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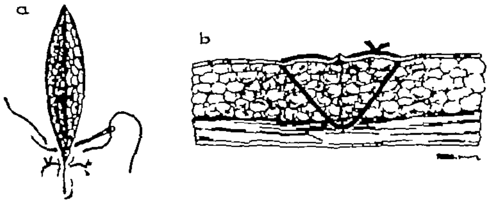


FIG 38 Method of passing McMillen's interrupted on-end mattress-suture. *a* suture passed through both margins of wound. Needle reversed and made to enter skin between point of emergence and wound margin and carried through tissues to opposite margin in similar manner Suture ends project on one side loop lies at right angles to wound on opposite side. *b* sectional view showing eversion of skin edges when suture is tied. This suture effects accurate apposition of skin margins, obliterates dead spaces, and reinforces subcutaneous tissues. (Davis)

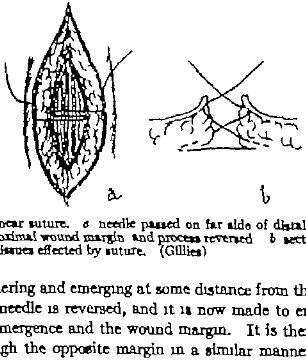


FIG 39 Near far far near suture. *a* needle passed on far side of distal wound margin, made to emerge on near side of proximal wound margin and process reversed *b* sectional view showing coaptation and relaxation of tissues effected by suture. (Gillies)

passed, the needle entering and emerging at some distance from the edges of the wound. The direction of the needle is reversed, and it is now made to enter the skin between its original point of emergence and the wound margin. It is then carried through the tissues to issue through the opposite margin in a similar manner, both ends lying on one side, the loop thus formed being at right angles to the wound. When the suture is tied, the lips are necessarily everted.

The 'near far far near suture' (fig 39) is valuable for the approximation of deep structures. The needle is passed through the subcutaneous tissues on the far side of the distal wound margin and made to emerge on the near side of the proximal wound

edge It is then carried across the wound and the procedure reversed, the suture entering the near side of the distal wound margin and emerging at the far side of the proximal wound edge This suture serves the double purpose of coaptation and relaxation and in addition prevents inversion of the wound edges

The pulley suture, like the above, combines the properties of the tension suture with those of the approximation suture The needle is made to enter the tissues on the far side of the distal wound margin and to emerge at an equal distance from the proximal margin, it is then passed into the tissues on the near side of the distal edge and made to issue at an equal distance from the proximal edge, whereupon the ends are tied

The continuous suture consists of a series of stitches running along uninterruptedly, only the first and last being tied Its advantage lies in the fact that it can be rapidly passed, that it insures good apposition of the wound margins, and involves fewer knots, but one objection to its use is that if any part of the suture gives way, the entire line of approximation is jeopardized Furthermore, it involves the difficulty of se-

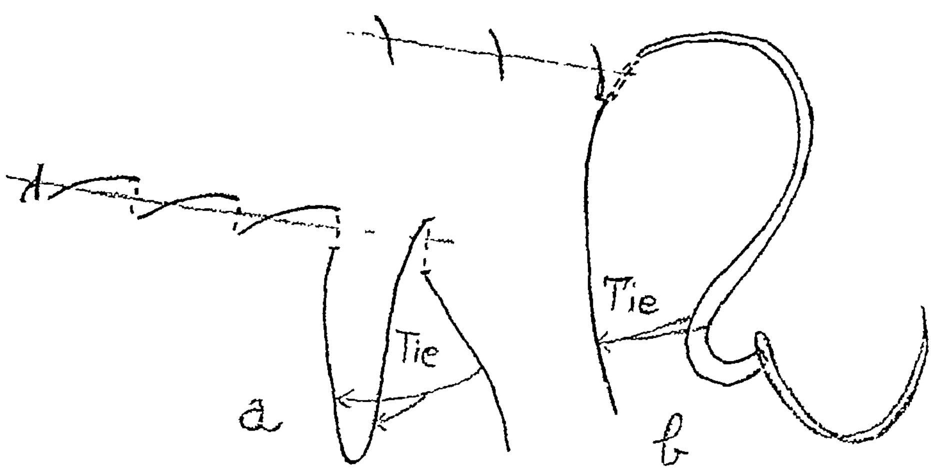
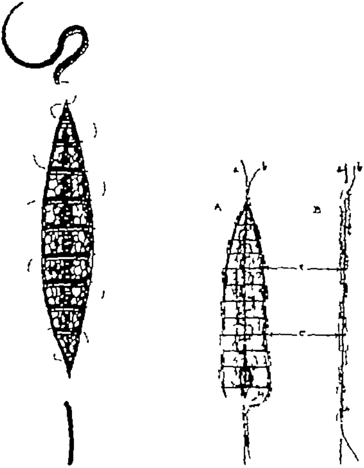


FIG 40 Methods of terminating continuous suture *a*, last suture drawn only partly through one side, so that loop remains, to be used to complete tying *b*, prior to last bite, needle adjusted, so that free end of suture will be left on distal side of wound, to be used to complete knot

curing even tension along the suture line unless the thread is kept taut The continuous suture may be in the form of (1) a whip stitch, (2) a lock or buttonhole stitch, or (3) a continuous mattress-stitch

The whip stitch, ("over-and-over" or glover stitch) comprises a series of continuous simple sutures running the entire length of the wound The technic is as follows An ordinary buttonhole stitch is made and tied One end is cut short and the other left long to complete the line of suturing The stitches are passed progressively, the assistant holding the thread of each completed suture taut with a forceps while the surgeon passes the succeeding one At the end of the series the last suture is drawn only partly through one side so that a loop remains, to be used to complete the tying Another method of terminating the continuous suture is as follows Just prior to the last bite the thread is adjusted on the needle in such a manner that the free end will be considerably longer than the other one, so that it will be left on the distal side of the wound after the last stitch has been passed This end is then tied to the loop in the needle on the opposite side (fig 40)

The lock stitch (buttonhole stitch) differs from the whip stitch in that the long end of the thread is passed around the needle point each time the latter emerges from the side of the wound. Thus a friction lock is produced. The procedure is as follows An ordinary simple interrupted suture is made and tied. The thread is held taut in the left hand, and with the right hand the needle is passed through the tissues in front of the thread. The terminal stitch is tied according to one of the methods already described. For greater security the thread may be doubly locked.



I II

FIG 41. Halsted's intradermic or subcuticular suture, employed when especially fine scar is desired. *I* needle introduced 0.5 cm. beyond one angle of wound and brought out at end. Needle engages corium at points 0.5 cm. apart, until entire wound is traversed. Suture then brought out 2 or 3 cm beyond angle of wound needle being kept close to skin and at same level on both sides *II*, double suture. *A–a*, deep suture. *A–b* superficial suture. *B*, suture tied. *c*, *c′* superficial suture brought out on skin surface every 2 or 3 cm. to facilitate its subsequent removal. For details see text.

The first stitch of a *continuous mattress suture* is passed in the same manner as a simple interrupted mattress-suture, and the subsequent stitches are made by a reversal of the direction of the needle each time it is passed, so that a series of loops are formed parallel with the line of incision on each side of the wound

Halsted's intradermic or subcuticular stitch (fig 41–I) is employed in areas where exact coaptation and a minimum of conspicuous scarring are especially desirable. The advantage of this suture is that it leaves no visible puncture holes on the skin, eliminates the danger of stitch abscess, can be left in place for a comparatively long period, and is easily removed. Its applicability is limited, however, to small straight

wounds where there is no disparity of length between the margins to be apposed Before the introduction of this type of stitch the deeper tissues must be carefully built up by a series of buried sutures, so that the margins of the wound will fall into easy apposition The procedure is as follows A fine curved needle threaded with fine silk is introduced into the skin 0 5 cm beyond the lower angle of the wound and brought

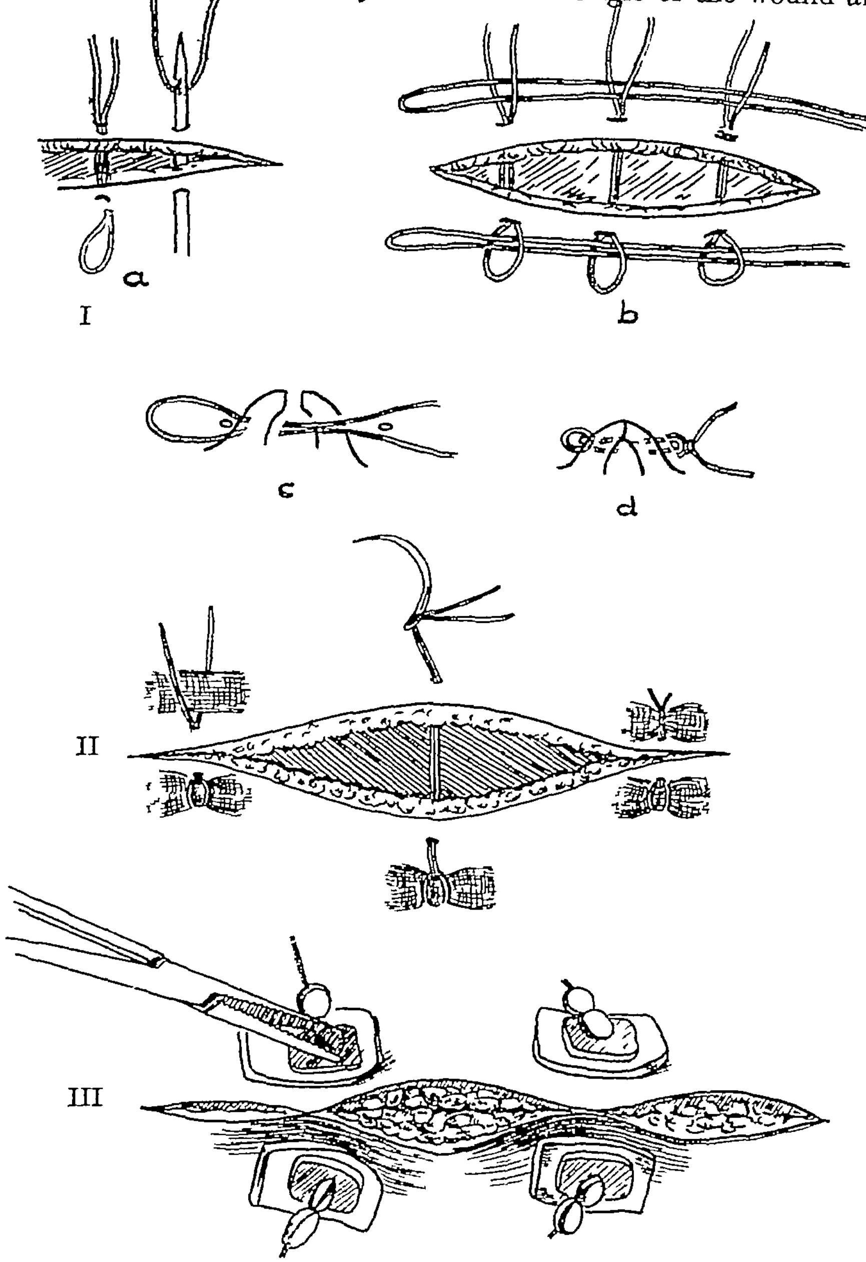


FIG 42 Types of sutures for wounds under tension *I*, Suture tied over strands of suture material *a*, suture drawn through with Reverdin needle, *b*, strands of silk placed between loops and between free ends, *c–d*, sectional views (Rocher) *II*, Suture tied over gauze roll *III*, Wire suture provided with lead beads, lead platelet, and rubber pad, while wire is held under tension, beads are compressed to fix suture (Kirschner)

out at the end of the wound A subcutaneous bite of the corium is taken on one side of the wound, followed by a similar bite on the opposite side at exactly the same level, care being taken that the needle is kept close to the skin surface but does not penetrate it The process is repeated, bites being taken on alternate sides 0 5 cm apart, until the entire wound is traversed The suture is then finally brought out through the

skin 2 to 3 cm. beyond the upper angle of the wound. The entire line is left loose until the last stitch is completed, at which time the wound edges are drawn together by the exertion of traction in opposite directions on both ends of the thread. In order to facilitate its subsequent removal, the suture is drawn back and forth several times The ends may be left free or they may be fastened to the skin with adhesive plaster or collodion. In the case of a long wound this suture will be easier to withdraw later if it is carried to the surface every 2 or 3 cm, the needle being brought out through the skin on one side and inserted on the opposite side (fig 41–II) After healing has taken place the external loop thus formed is cut through, and the suture removed in sections In wounds under considerable tension two subcuticular sutures may be passed, one above the other, in the manner described above

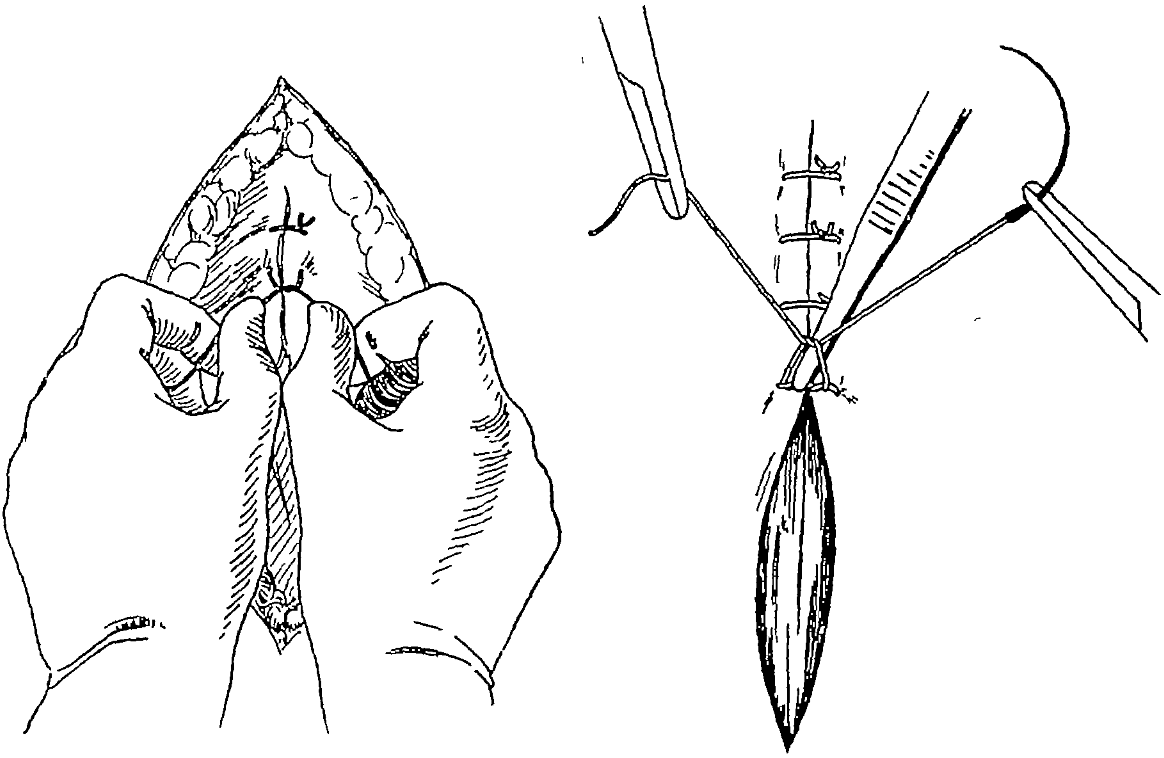
In cases where there is considerable tension on the wound, tearing out of sutures can be prevented if the ends are tied over buttons metal plates, strands of suture material, glass rods, tubing, or beads, or if a roll of gauze or a strip of rubber tubing is inserted beneath the loops on both sides (bolster or quill suture) (fig 42)

When the wound is of such nature that a certain amount of tension is unavoidable, the use of *relaxation sutures* is indicated for the purpose of transferring the tension from the line of the wound to more distant parts. The greater the absorption of tension required, the farther away from the wound margin should these sutures be placed and the more tissue should be incorporated in the bite.

Methods of Tying Upon the manner in which the suture is tied depends in a large measure the integrity of the wound and the insurance against postoperative bleeding In the interests of accuracy, speed, and nicety of manipulation certain general principles must be adhered to in the tying of surgical knots The first turn of all knots is a simple loop which should be made slowly and firmly with both thumbs close to the knot and just enough tension applied so that the wound margins will be brought into direct contact (fig 43a) The plane of the loop should correspond to the sagittal plane of the operator's body, traction being exerted by one hand pulling toward the body and the other away from it Crossing or changing of hands is to be avoided, as it is awkward and time-consuming and results in a distorted knot Too many loops should not be made, as they increase the bulk of the suture and accentuate the tissue reaction If the first knot tends to slip, it may be supported by means of a forceps held by an assistant (fig 43b), or a friction knot may be tied. The second tie of all knots should be brought down flat and snugly over the first, care being taken not to tighten or loosen the first loop during the procedure. In the case of especially important sutures or ligatures or those subject to tension it is best to resort to 3 knots instead of 2 If catgut is used, the ends should be left 5 to 6 mm. long, for if they are cut too short, the knot may become untied as the catgut softens. In the case of silk or linen, however, the ends can safely be cut just above the knot, as this material has but little tendency to slip In skin sutures, especially where the bite was made close to the wound margin, the ends are left long to facilitate subsequent removal

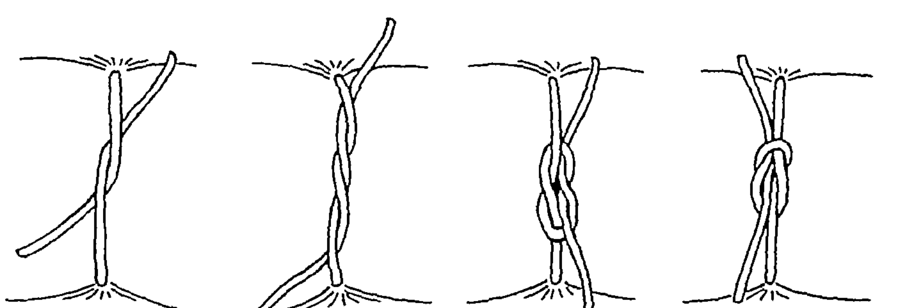
The *simple knot* (fig 44a) forms the basis of all surgical knots and is made by passing one end of a suture completely around the other end, and is tightened by drawing both ends along the plane of the loop and away from one another The *friction knot* (compound knot) (fig 44b) is made similarly, except that the free end is passed 2 or more times around the stationary end thereby increasing the surface friction and

diminishing the likelihood of slipping The *square knot* (reef knot) (fig. 44d) is the one most frequently used in surgery, as it has no tendency to become untied, resists pressure from within, and lies flat It is tied in such a manner that one vertical limb



a b

FIG 43 Method of tying knot *a*, first turn is a simple loop, made slowly and firmly, with both thumbs exerting divergent traction close to knot, and just enough tension used so that wound margins will be brought in contact *b*, first knot supported by forceps, to prevent slipping while second is being tied



a b c d

FIG 44 Types of knots From left to right *a*, simple knot One end of suture passed completely around other end and tightened by drawing ends away from one another along plane of loop *b*, friction knot Free end passed two or more times around stationary end, thereby increasing surface friction and diminishing likelihood of slipping *c*, granny knot, rarely used owing to its tendency to slip One end of suture above and other beneath horizontal loops *d*, square knot (reef knot), type most frequently used in surgery, as it has no tendency to slip, resists pressure from within, and lies flat One vertical limb of loop passes in front, and other in back of horizontal limbs, so that loops on each side pass over both strands

of the loop passes in front and the other vertical limb in back of the horizontal limbs, the loops on each side passing over both strands of thread The *surgeon's knot* consists of a double twist in the first tie (friction knot) and a single one in the second

The purpose of the double turn in the first tie is to secure the suture against slipping while the second is being tied Despite this advantage, the surgeon's knot is rarely used, because it is bulky and because the two turns make it difficult to gauge the amount of pressure being exerted on the tissues and the amount being absorbed by the friction of the double loop The *granny knot* is a double knot, in the second loop of which the end of one thread is above and the other beneath the horizontal loops, causing the loops to lie in the same plane. In tying the first loop, the end is passed through the loop away from the operator, but in tying the second half of the knot the

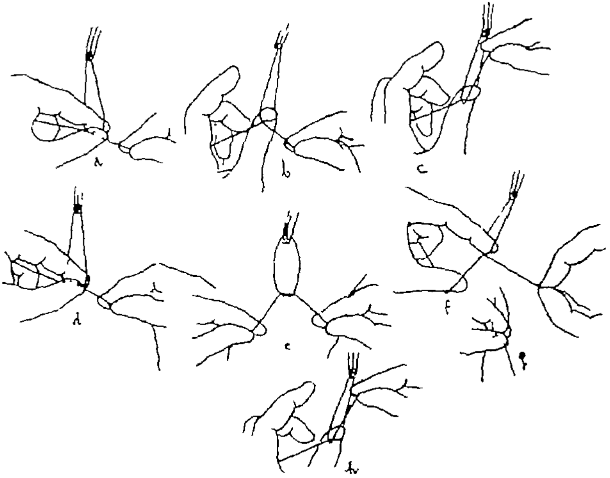


FIG 45 Two-hand tying of knot. *a* first turn of square knot, with left index finger within and *thumb outside loop* *b*, *left thumb turned up and lying within loop* *c* *short end of thread laid across* left thumb. *d* left index finger pushing thread out of loop. *e*, both ends of thread drawn apart, to complete first turn of knot. *f* long end of thread looped under extended left thumb and over flexed ring finger while left forefinger presses down first loop. *g* *left forefinger inside*, and left thumb outside first loop *h*, left thumb thrust inside loop and second turn of knot completed. (Spivack)

same end is carried through the second loop toward the operator This knot is rarely used, owing to its tendency to slip The *slip knot* is one which can be readily adjusted and untied and is resorted to in cases where frequent adjustments are necessary, as when a drain must be held in place in the deeper part of a wound. The *stay knot* finds its chief application in the obliteration of large blood vessels. It is made by passing two independent sutures around the vessel and tying each ligature separately with a single knot. The two ends are then picked up on each side and tied in a square knot. The *Staffordshire knot* is used mainly where transfixion of tissues is required. It is made by passing a doubled ligature through the pedicle, the looped end

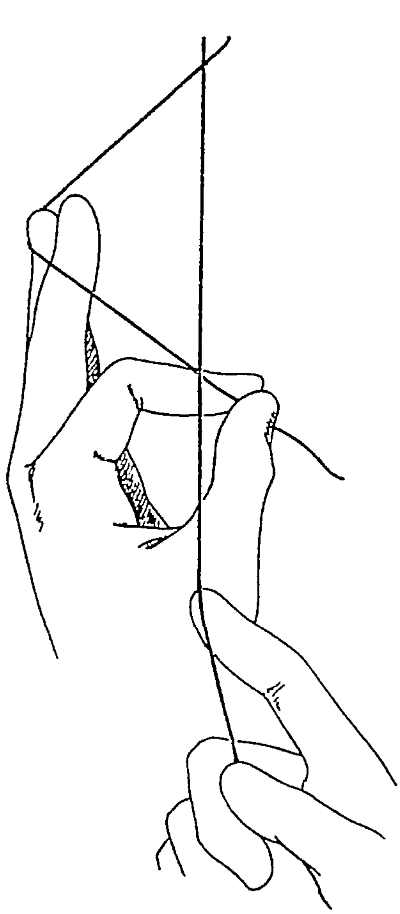


FIG 47 One-hand tying of knot (Printy)

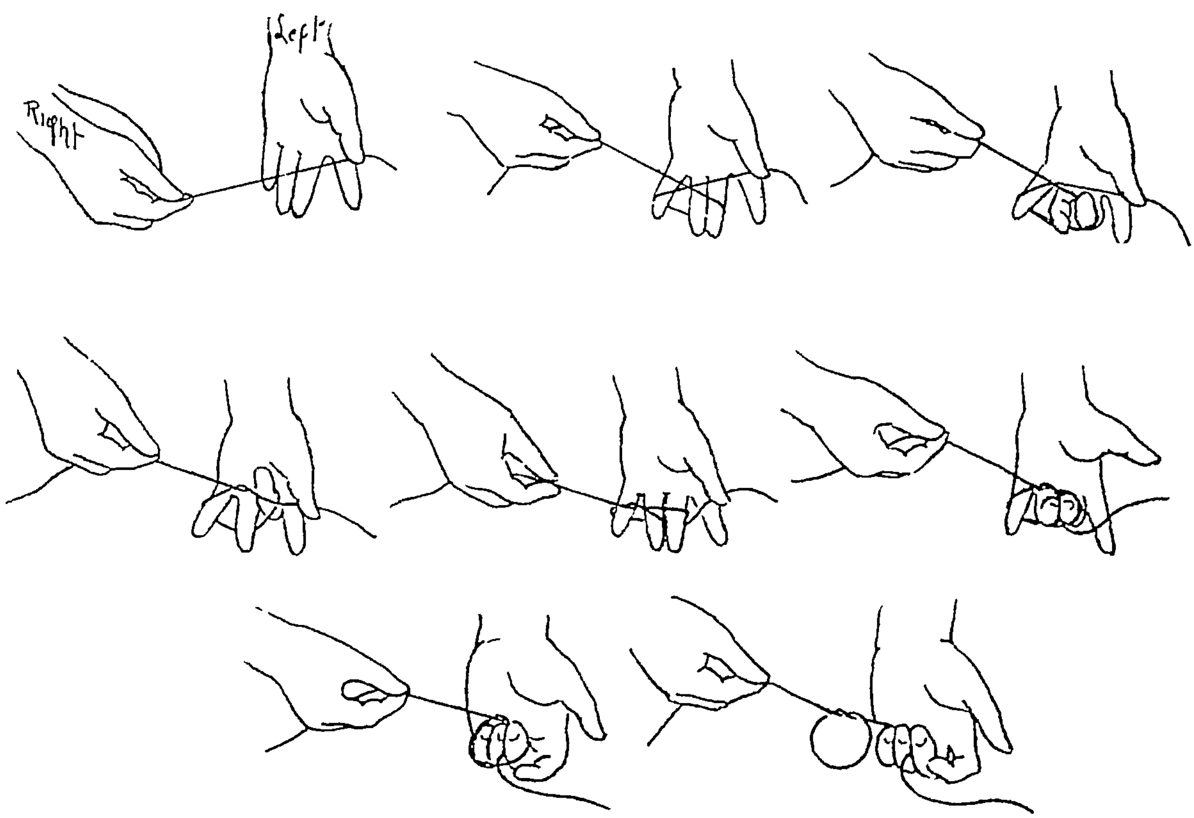


FIG 48 A simple method for tying suture with left hand

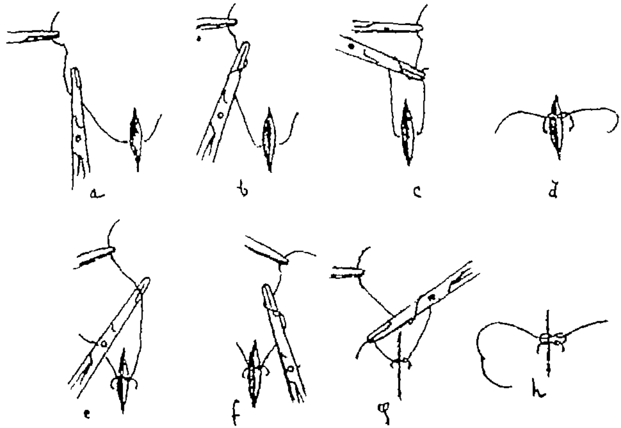


FIG. 49 Grant's "no-hand-touch" method of tying knot. This method is economical of suture material and can be carried out with speed and finesse. *a*, long end of thread held with forceps in left hand and needle holder laid *over* it. *b*, by circular motion, suture wound loosely around holder *c*, thread-encircled holder grasps short end of suture and carries it through loop. *d* first tie completed by traction with both hands pulling in opposite directions. *e*, procedure repeated, except that needle holder is placed *under* suture. *f* by circular motion suture loosely wound around holder *g* thread encircled holder draws short end of suture through loop *h* knot completed.

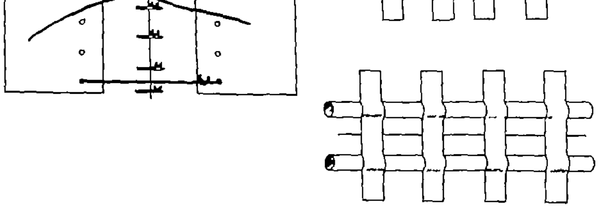


FIG. 50 Methods of supporting wound margins. Two strips of muslin attached to skin margins with adhesive tape and laced together over wound. Strips of adhesive tape laid across wound. Strips of adhesive tape applied over bolsters laid parallel to and on either side of wound margins.

muslin to which hooks have been sewn and lacing them together in the manner of a corset The use of these methods of approximation must obviously be limited to superficial wounds which are under no tension, and even in such cases the appearance of the ultimate scar will be inferior to that resulting from carefully applied sutures

The Dressing

After the operation the skin in the vicinity of the operative field is cleansed by sponging with normal salt solution In clean wounds on exposed surfaces where no oozing is anticipated and no drain has been introduced, the line of incision is painted with Whitehead's varnish and exposed to the air Under all other circumstances a dressing is applied for the protection of the wound against local irritation from wound secretions, trauma, and contamination, and in order to keep the part at rest It is scarcely necessary to add that the portion of the dressing destined to come in contact with the wound should be sterile The exact size of the dressing and the material to be used cannot be arbitrarily stated, in view of the varying character of operative wounds. If the wound has been closed without recourse to drainage, a few layers of sterile gauze held in place by a bandage will be sufficient, but if discharges are expected, it will be found advisable to apply a larger dressing for the absorption of the secretions The dressing is applied with the patient in the position he will later assume in bed, in order that its relation to the wound may remain the same

The various types of dressings and their methods of application are described in the special sections

Operative Routine

A systematized operative routine is essential to speed, efficiency, and economy, and these desiderata can be achieved only by the studied endeavor and harmonious co-operation of a team accustomed to working together year after year Frequent changes in personnel and repeated deviations from the customary technic interfere with the development of that machinelike co-ordination necessary to meet the demands of the operation and to cope with the contingencies that may arise A well-organized routine implies that every detail of the operation has been previously arranged, that a given number of instruments will be on the tray, each in its proper place, and that every movement will serve a definite purpose It is the responsibility of the surgeon to maintain the morale of the operating staff, instruct the assistants in their duties, and see to it that these duties are properly carried out The number of persons necessary to insure smooth performance and asepsis in a given operation is a matter of opinion The present trend is to limit the number, and the better the organization, the fewer will be required Probably the surgeon, one or two assistants, a fully sterilized nurse, a non-sterilized utility nurse, and the anesthetist are sufficient for the ordinary operation

While the details of the aseptic ritual vary in different hospitals, the underlying principles are the same in every case and have been well summarized by that distinguished surgeon, Sir Berkeley Moynihan: "Every operation in surgery is an experiment in bacteriology The success of the experiment in respect of the salvation of the patient, the quality of healing in the wound, the amount of local or constitutional

reaction, the discomforts during the days following operation, and the nature and severity of any possible sequelae, depend not only on the skill but also upon the care exercised by the surgeon in the ritual of the operation The 'ritualist' must not be a man unduly concerned with fixed forms and ceremonies, with carrying out the rigidly prescribed ordinances of the surgical sect to which he owes allegiance, but a man who, while observing with unfaltering loyalty those practices which experience and experiment have altogether imposed upon him refuses to be merely a mimic bound by custom and routine He must set endeavor in continual motion, and seek always and earnestly for simpler methods and a better way In the craft of surgery the master work is simplicity"

It is customary for the surgeon to notify the operating room supervisor of the contemplated operation and its nature far enough in advance to permit of scheduling the time for the benefit of visiting physicians and to facilitate the selection and preparation of the operating room and the assembling of the necessary instruments, solutions, wearing apparel, sponges, dressings drapes, etc. The character of the operation will determine the assignment of the operating room. In hospitals where clean and unclean cases are treated in the same room it is customary to schedule the clean cases first. Once the hour of operation has been posted, every effort should be made to observe the appointed time, since a delay not only is harmful to the patient's mental state but also upsets the schedule for subsequent operations.

Preoperative "Set Up." The operating room "set up" is begun from one half to one hour before the time set for operation. The room having been previously cleaned, the surgical nurse makes the necessary preparations. From the instrument cabinet she removes the basic set of instruments and whatever special instruments are necessary for the particular operation. The list chosen should be sufficiently complete to meet *all* possible demands of the surgeon, since an omitted instrument called for during the operation not only causes delay but disposes to hurried and ineffectual sterilization The list should include an infusion and a transfusion set, an approved airway, a tracheotomy set, a pair of tongue forceps, and a mouth gag for use in the event of an emergency, such as hemorrhage, shock, or asphyxia, during the course of the operation All non-cutting instruments are placed in the tray of the instrument sterilizer and left to boil for ½ hour while the cutting instruments are immersed in phenol solution. Pans, trays, pitchers, pus basins, and other enamel ware are put into the utensil sterilizer and are likewise boiled for ½ hour The drums containing sterilized gowns, dressings, sponges, and drapes are taken out of the autoclave and transferred to the operating room.

While the instruments are being sterilized, the operating room equipment is arranged. On the anesthetist's table are placed pus basins, tongue forceps, mouth gags, dressings, castor oil, a sterile hypodermic syringe and needle, and stimulants, such as adrenalin, *ephedrin, caffein, pituitarin*, strychnin, morphin, and atropin. In the drawer of the table are put towels, safety pins, and airways The arrangement of the gas-oxygen machine is personally supervised by the anesthetist. If the operative site is to be prepared with soap and water, a special table is set up on which is placed a supply of gauze and cotton sponges and sterile basins containing green soap, sterile water, alcohol, and ether

Twenty minutes before the operation the sterile nurse dons a cap and mask, scrubs

up in the manner already described, puts on a sterile gown and gloves, and proceeds to drape and equip the various tables All tables are completely covered with sterile sheets and their tops overlaid with sterile towels On the *glove table* are placed sterile hand towels, sterile gloves, and powder packets, all of which are covered with a sterile towel. The *basins* are placed in the solution stands, one filled with alcohol and the other with normal salt solution The *instrument tables* are next prepared Inasmuch as some instruments are used almost constantly and others only occasionally, they should, for the sake of convenience, be distributed on two tables, a large one designed for the reserve supply and a smaller one for those in constant use The instruments, when once arranged, should be maintained in a definite order throughout the operation, so that they may be instantly located when needed, and so that any omission may be quickly detected Pointed instruments are placed with their points downward so that, when picked up, they will not tear the gloves Handles are so oriented that when an instrument is grasped, it will be in the proper position for immediate use On the *reserve table* is placed the set of instruments from which the main supply on the smaller table is to be replenished when necessary, and, in addition, towels, sponges, drapes, and the requisites for suturing On this table the articles are grouped according to their functions—for instance, the instruments destined for cutting are laid out in one place, those for holding tissues in another, etc Finally, on a small *instrument table* (*Mayo table*) is placed a limited assortment of instruments to meet the surgeon's immediate demands, and this set is replenished from the reserve table as the occasion requires The articles, like those on the reserve table, should be in definite groups—those for the surgeon on the right, those for the assistant on the left, sponges in the center, and special instruments in the rear The surgeon's and assistant's instruments are arranged as nearly as possible in the order in which they will be used If a separate table is employed for *suture material*, it should be located near the reserve table and equipped with a needle holder, an aneurysm needle, a pair of suture scissors, needles, and suture material Catgut tubes, having been removed from the jar with sterile forceps, are broken, and the suture material immersed in a small tray containing 70 per cent alcohol Non-absorbable suture material is deposited in a tray of sterile water With forceps several needles are threaded with the required sutures and placed between the folds of a towel in the order in which they are likely to be used

Anesthesia and Preparation of Patient Twenty minutes before the time scheduled for the operation the patient, accompanied by a nurse, is wheeled on a stretcher into the anesthetizing room The patient's chart is sent up with him and on this sheet is recorded the time when he last voided, the presence or absence of any foreign bodies in the mouth, the character of the preliminary medication, etc Attached to the chart is the patient's written consent to the operation and any x-ray plates that may have been made As soon as the surgeon arrives, anesthetization is begun When the patient has reached the stage of light anesthesia, he is wheeled into the operating room

The position in which he is to be placed will obviously depend upon the nature of the contemplated operation It should permit of a convenient exposure of the operative site, and at the same time should cause no interference with respiration or undue pressure on nerves and blood vessels The position most frequently used is the dorsal, wherein the patient lies on his back with his arms to the side Special

precautions should be taken to avoid pressure on the arms from the edge of the table, as this may lead to radial paralysis The arms may be held out of harm's way by means of a small folded sheet passed under the body, looped around the arms, and held in place with safety pins The elbows are supported on pillows and either the hands are placed beneath the buttocks, with fingers extended and palms turned down, or the wrists are tied to the side of the table. Bartlett (2) suggests that the wrists be wrapped in a small towel encircled by a doubled muslin bandage, the ends of which are pulled through the loop in the manner of a slip noose and attached to the side of the table (fig 51) The folded towel under the noose prevents interference with the circulation of the hand and injury to the nerve. Sandbags or pillows can often be used to advantage for steadying or raising the part under consideration. Operations on the upper extremities will be facilitated if the arm is laid in a position of abduction on an extension board attached to the side of the table. In such cases care should be taken to protect the brachial plexus. Special positions will be described in the appropriate sections.

The utility nurse exposes the operative site, and the second assistant, after the preliminary scrubbing up, dons a pair of sterile gloves but no gown, outlines the area

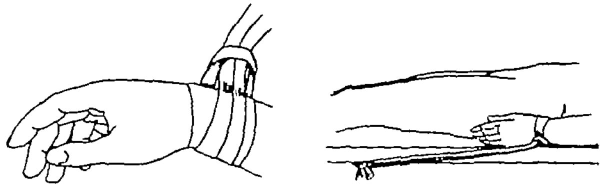


FIG 51 Method of fixing patient's arms to side of table. Wrist wrapped in small towel, encircled by doubled muslin bandages, ends drawn through loop in slip noose, and fastened to side of table. (Bartlett)

with 4 sterile towels, and prepares it for operation in the manner already described (p 5) If the part is to be cleansed with soap and water, he uses the table set up for the purpose; if iodin is to be used, it is applied with a sponge held in a long forceps, after which both sponge and forceps are discarded in a bucket. The iodin is then removed with an alcohol sponge which is also discarded. After having sterilized the operative site the assistant removes his gloves without contaminating his hands, scrubs up once again for 3 minutes with soap and water and for 2 minutes with alcohol. If his hands have been inadvertently contaminated during the removal of the gloves, he will be obliged to go through the entire formal procedure of hand preparation He then dons a sterile gown and gloves and stands ready to assist in the operation.

The patient is draped by the first and second assistants. The operative area is outlined with 4 sterile towels, and over these is laid a sheet furnished with a slit or round opening which is fitted over the operative site The upper end of the sheet is unrolled and brought over the anesthetist's screen, the lower part is drawn over the patient's feet, and the sides are rolled down to cover the operating table The towels and the sheet are secured in place by means of 4 towel-clamps, the teeth of the clamps passing through the sheet, the towel, and the skin of the patient. The im-

mediate site of operation is further isolated with additional towels placed above and below it If the operation cannot be started directly after the sterilization process, the prepared site is covered with a sterile towel After the patient has been draped, the small instrument table is equipped and swung over into the vicinity of the operative field

Preparation of Surgeon While the patient is being anesthetized and the operative site prepared, the surgeon scrubs up With his hands still wet he turns back the sterile cover of the towel table, picks up a towel and dries his hands He then dons a sterile gown, holding it well away from his body (fig 2) Crossing his arms in front, in order to protect the elbows, he holds the tapes for the unsterile nurse to tie, after which he dusts his hands with the powder packet on the glove table and dons a pair of sterile gloves in the manner already described (fig 3)

The Incision. The surgeon takes a position to the right of the patient, the first assistant stands on the opposite side, facing the surgeon, and the second assistant stands to the right of the surgeon The surgical nurse occupies a position convenient to the surgeon to facilitate the passage of instruments The skin incision is made and the knife discarded Bleeding vessels are caught with hemostats and ligated, and while the surgeon rinses his hands, the assistants apply the wound-towels, so that during the remainder of the operation no skin surface will come in contact with the hands of the personnel or with any sterile objects

In operations which demand a shifting from one site to another—for example, in a grafting operation, or when an infected focus has been inadvertently opened during the procedure—the operating squad effects a complete change of sterile raiment, and all instruments are discarded and replaced with a completely fresh sterilized set before the operation is proceeded with

The First Assistant. Throughout the operation the first assistant strives to keep the wound free from blood by frequent recourse to suction and the use of hemostats applied to the severed vessels He assists the operator in the ligation of bleeding vessels by elevating the handle of the hemostat to allow the ligature to pass around it, raising the tip of the instrument to facilitate the tying, and cutting the ligature after the hemostat has been removed As each instrument is used, it is the assistant's duty to supervise its cleansing and replacement While sutures are being passed, he holds the end of the thread to keep it from dragging, and as the needle emerges through the tissues he grasps its point and pulls it through After the operation he prepares a written account of the procedure, including the method of preparation, the operative technic, the nature of the pathologic lesion, and the method of closure If a packing or drain has been left in the wound, he records the fact on the chart, and if a tourniquet has been used, he notes the time of its application and removal

The Instrument Nurse. A competent instrument nurse can add much to the surgeon's tranquility of mind by anticipating his wants, so that no instrument or sponge will need to be called for Throughout the operation it is her duty to keep the sterile supplies in good order She replaces soiled instruments with sterile ones from the reserve table, lifting them with a sterile forceps and dropping them on the Mayo table, being careful not to touch the table with the forceps In the interests of safety it is a good rule to consider all operative cases as infected, and once an instrument has been taken from the reserve table, it should never be returned there When-

ever a needle is laid down the nurse picks it up with a sterile forceps, rethreads it, and places it in a needle holder ready for use She is ever watchful for any break in the technic which may have escaped the eye of the surgeon or the assistant.

The Utility Nurse. The duty of the non-sterile nurse is one of general utility She uncovers the patient for the preparation of the operative site secures the arms, adjusts the restraining straps over the knees, and aids in the skin preparation by holding the basin of green soap and pouring alcohol or water as required. She ties the sterile gowns, connects the suction apparatus, wheels the cautery into place, and holds additional lights when necessary During the operation she remains in the operating room and supervises the general cleanliness transports supplies, pours solutions, attends to the sterilizer, and picks up fallen instruments and resterilizes them. Some of her other duties include wiping the brows of the sterilized personnel, adjusting the operating table when necessary, administering hypodermics and counting discarded sponges At the completion of the operation she sees to it that pathologic specimens are put up in a 4 per cent solution of formalin and sent to the laboratory properly marked with the names of the surgeon and patient, the date, and the tentative diagnosis.

Immediate Postoperative Care At the close of the operation all sponges, packs, and instruments having been accounted for and those not recovered having been noted on the chart for subsequent removal the wound is closed and the dressing applied. The patient s body is dried and all wet clothing removed and replaced with dry Before the patient leaves the operating room, the surgeon assures himself that there is no evidence of hemorrhage or shock as manifested by the color of the skin, the quality and regularity of the pulse, the condition of the blood pressure, and the temperature If respiration is obstructed due to a falling back of the tongue into the pharynx, a stitch is passed through the tip and left in position until the reflexes return If there has been a considerable loss of blood and the state of the patient demands a transfusion immediate arrangements are made for the procedure. If shock is imminent, the appropriate measures are taken while the patient is still in the operating room. As soon as his condition is satisfactory, he is transferred to the recovery room and remains there until he recovers from the anesthetic. This will preclude the possibility of chilling and the trauma that would otherwise be occasioned by the more extended journey to his room. Furthermore, should an accident such as hemorrhage occur he will be conveniently situated to receive the necessary aid.

In the transportation of the patient all unnecessary movements should be avoided, and those that are unavoidable should be made gently and slowly Much unnecessary manipulation can be obviated if the patient is removed to the recovery room while still on the operating table or if a previously warmed bed is wheeled into the operating room and the patient transferred directly into it. If the carriage is to be used for the purpose it is wheeled in by an orderly and placed beside the operating table The two assistants take positions opposite each other, one beside the carriage, the other next to the operating table, clasp hands beneath the trunk of the patient, and with the anesthetist supporting his head and the nurse his legs, they transfer him gently onto the carriage. The sleeves are pinned to the sides of the gown as a protection against injury to the arms, the blankets are folded over the body, and the head is covered to prevent chilling from the inspiration of cold air He is then expeditiously transported to the recovery room, accompanied by the anesthetist and the assistant.

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CHAPTER II

TISSUE TRANSPLANTATION

Tissue transplantation falls into two main divisions, grafts and flaps By the term "graft" is understood a mass of living tissue completely detached from its original site for the purpose of implantation into another area from which it must receive its sole nourishment The term "flap" implies a mass of living tissue detached from its underlying support but which, unlike a graft, retains a partial connection with its original site by means of a pedicle of tissue through which it receives its main sustenance after transplantation

Before embarking upon a practical discussion, certain guideposts along the trail which has been followed in an attempt to standardize the technic will be given, as they are essential to a clear understanding of the subject

The literature of antiquity shows tissue transplantation being practiced on a highly developed scale in ages yet unilluminated by science, the earliest reference to the art having been mainly concerned with the correction of noses damaged by the ravages of syphilis and by the avenging knife of the conquering enemy or the outraged husband The Ebers Papyrus (1500 B C) shows that grafting of tissues was practiced by the Egyptians as far back as 3500 B C , and the Sacred Vedas, or holy books, of equal antiquity, reveal that both flap and grafting operations were well known among the ancient Hindus Susruta "whose work is the great storehouse of Aryan surgery" (331) relates that a certain Hindu caste, the Koomas, or potters, made use of grafts from the gluteal region They prepared the donor area by beating the skin of the buttocks with a wooden shoe until it was quite red A pattern of the defect was cut from a leaf, placed on the reddened area, and outlined by an incision The section of skin so marked was excised together with its subcutaneous fat and immediately united by a secret "cement" to the previously freshened edges of the defect In the light of present knowledge it would seem that the number of successful transplantations must have been very small, since the inclusion of the underlying fat on the graft, to say nothing of the lack of asepsis, certainly would not speak for satisfactory results

According to Carpue (45), the art spread from Egypt and India to the southern parts of Asia, to Persia and Arabia, and thence to Greece, afterward it passed to Calabria, and from there into other parts of Italy This is probably true, since Egyptian literature sooner or later reached the different Mediterranean civilizations Indian culture was known to have been transmitted to the Persians and later to the Arabs, and Egyptian, Grecian, and Phoenician cultures penetrated into Italy as a result of the Roman wars

The progress of tissue transplantation, like science as a whole, followed the rise and fall of empires The first century finds Rome a medical center with primitive surgery donning the mantle of Indian culture, and tissue transplantation flourishing

as a fine art. From all the talent, two names stand out—Celsus and Galen. Celsus (53 B C -7 A.D), born in Rome during the reign of Augustus shortly after the birth of Christ, reflecting the Alexandrian school of medicine, wrote with authority in his "De Medicina" on the transplantation of tissues from one part of the body to another He believed that all living tissues were capable of being transplanted and that they could live and thrive in their new location. Galen (130-210 A.D), a Grecian physician who had migrated to Rome, reflecting the Hippocratic school, more than anyone else showed the brilliant position of reparative surgery during the greatness of imperial Rome He gave minute instructions regarding the repair of defects about the nose, ears, and mouth. He advised the removal of all scar tissue and approximation of wound margins by sutures and by sticking plaster Unfortunately, however, much of his writing was spurious, fantastic and unscientific, but so sacrosanct were his teachings that to refute them was tantamount to lèse majesté, and for many centuries his 'dead hand" continued to retard medical progress. Nevertheless, he was the last great physician of antiquity Shortly after his death the dissolution of the Roman Empire under the barbarian hordes plunged all Europe into the abyss known as the Dark Ages. Christianity flowing over the Western World was being "fought with words, steel and fire." In this period of strife and bloodshed, the light of all science grew dim, flickered, and nearly went out, and what was known of tissue transplantation was forgotten. Eventually Christianity triumphed, but throughout the remainder of the Middle Ages no contributions were made to surgery During the thirteenth century the medieval ecclesiastics were forbidden by Pope Innocent III to perform surgical operations, and later it was considered beneath the dignity of an educated physician to practice surgery because it was deemed a manual occupation This general attitude was expressed by Giovanni de Vigo "Operations are unworthy of a physician and should be left to the itinerant and inferior surgeon."

In the *fifteenth* and sixteenth centuries, however, when the revival of learning was combating the scholasticism of the Middle Ages, the art of tissue transplantation by means of skin flaps was resurrected in Europe But since the operation was concerned mainly with rhinoplasty, its evolution will be detailed in the chapter devoted to nasal surgery, and only brief mention of it will be made at this time Peter Rosano, Bishop of Lucera, related in the eighth volume of his "Annals of the World" that in the year 1442 one Branca, a "wound doctor" from Catania, reintroduced the ancient Indian method of using flaps from adjacent areas of the cheek or forehead for the repair of facial defects. Branca's son, Antonius, to avoid additional scarring of the face, modified his father's method by utilizing the skin of the arm From the Brancas, or more likely from their pupils, the flap operation passed from Sicily to another family of itinerant surgeons the Boiani or Vionei of Calabria (88) Alexander Benedictus or Benedetti, professor at Padua, writing of the Bolani family, stated "During my time [about the commencement of the sixteenth century] they also learned to correct the deformity of the nose. A flap is detached from the arm and cut in the form of a nose to be applied to the stump of a nose. They detach the skin from the arm with a bistoury, scarifying the nose and attach the arm to the head, in such a manner that the two wounds are applied one to the other When union is perfect they cut off, with admirable skill, as much skin of the arm as is necessary to form a nose. But this artificial nose endures with difficulty a hard winter, and when first put on it is very

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necessary to guard against having it pulled because it is liable to be pulled off." Credit for the origin of arm flaps, however, is generally given to Gasparo Tagliacozzi (334)

FIG 52 GASPARO TAGLIACOZZI

The history of this portrait is interesting A portrait of Paré, the father of French surgery, reputed to have been painted by Pourbus, the elder, was presented to the Faculty of Medicine in Paris in 1852 In 1903 the painting was sent to the Louvre to be cleaned and restored In the process evidences of a second medallion bearing the inscription "Coelum non Solum A D 1593 Age 46" was seen underneath the medallion naming Paré It is assumed that the false superinscription was added to obtain a higher price for the portrait The question naturally arose as to the identity of the subject The figures "A D 1593 Age 46" gave a clue. Tagliacozzi was born in 1546 or 1547 and in 1593 would have been 46 or 47 years old His treatise, published in 1597, afforded additional evidence The costumes worn by his patients closely resembled that seen in the painting As no portrait of Tagliacozzi could be found in the National Library at Paris, a photograph of the painting in question was sent to the authorities in Bologna to ascertain if it might not be Tagliacozzi The following is the answer to that query

"Bologna,
September 21, 1909

"The photograph of the portrait you sent me is surely that of Gasparo Tagliacozzi, the celebrated anatomist of Bologna, to whom is dedicated an inscription in marble and a statue, by A Levanti, which stands in the Theatre of the Anatomical Institute I enclose a photograph of the statue Both photographs correspond perfectly

Albano Sorbelli,
Librarian (Library of Bologna)"

(N Legrand—La France Médicale, 1909)

(1546–1599), Professor of Anatomy at Bologna, who was the first to write scientifically and philosophically of the method. In 1597 he published in folio at Venice his treatise

on the subject entitled "De Curtorum Chirurgia per Insitionem Libri Duo, Additus Cutis Traducis Instrumentorum Omnium atque Deligationum Iconibus et Tabulis" (figs. 52–53), of which Carpue (45) wrote "This scarce and singular work is comprised in two books, of which the first contains twenty five chapters, and the second twenty, illustrated with numerous engravings on wood In the front of the volume, are thirteen Latin and Greek poems, addressed to the author by his friends and from which we may collect the general esteem in which he lived" That the work of the

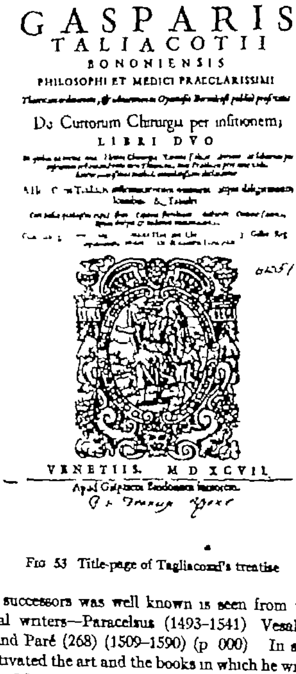
GASPARIS
TALIACOTII
BONONIENSIS
PHILOSOPHI ET MEDICI PRAECLARISSIMI
De Curtorum Chirurgia per insitionem,
LIBRI DVO
VENETIIS. M D XCVII.

Fig 53 Title-page of Tagliacozzi's treatise

Boianis and of their successors was well known is seen from the references to it by contemporary medical writers—Paracelsus (1493–1541) Vesalius (1514–1564), Fallopius (1523–1562), and Paré (268) (1509–1590) (p 000) In spite of the ardor with which Tagliacozzi cultivated the art and the books in which he wrote of it, the operation died with the author Many factors contributed to this. The theologians of his time bitterly attacked him accusing him of impiously "interfering with the handiwork of God," and attributing his success to the intervention of the "Evil One" Toward the

end of the eighteenth century the University of Paris put a ban on all such types of operation, and with this it seemed that the ghost of tissue transplantation had been laid forever.

But, as fate would have it, at this very time the feasibility of the operation was again brought to light The British East India Company had penetrated into India, and reports were brought back to England of the use of the Indian forehead flap In an article published in the Gentleman's Magazine for October, 1794, under the title "Pennant's Views of Hindoostan," there appeared a description of a rhinoplastic procedure which can reasonably be identified with that practiced in India from time immemorial, inasmuch as India—held in the bonds of her ancient caste system and unaffected by outside civilizations—had remained unchanged throughout the ages (fig 383) Influenced by these reports, Carpue (45) (1814) in England, von Graefe (139) (1816) and Dieffenbach (84) (1829) in Germany, Lisfranc (210) (1826) in France, and Warren (351) (1837) in America became convinced of the practicability of the operation and made use of it (p 753) South (316), writing in 1847, stated that the use of a flap was so common in England that cases were not reported

The art of *free tissue transplantation*, however, was not resurrected until the middle of the nineteenth century, although isolated operations of this nature were recorded from time to time A more or less apocryphal instance is related by Sancassani (303) (1731) of an itinerant street-vender of medicines, who, in order to prove the efficacy of a certain salve, was accustomed to cut a piece of skin from her leg, pass it around the audience upon a plate, and then replace it, covering it with her much-vaunted salve. It was said such perfect union took place that the site of the operation was scarcely discernible (117) In 1869 Reverdin (294) (fig 54) a Swiss surgeon, working in Guyon's service in the Hôpital Necker, Paris, demonstrated the possibility of successfully transplanting living pieces of epidermis to a granulating area, and upon this demonstration are based the theory and practice of skin grafting as it is done today His clinical application was prompted by his observation of islands of epithelium in the midst of granulations Accepting Billroth's explanation that these islands arose from proliferations either of the epithelium of the skin glands or of scattered bits of the germinal layer of epidermis, it occurred to Reverdin that epithelization of granulating surfaces might be expedited by the *artificial implantation* of small islands of epithelium Accordingly, he took the opportunity to demonstrate the practicability of the procedure in a patient who had lost the skin of his thumb With the point of a lancet he cut from the patient's arm two morsels of epidermis, each about 1 mm square, transplanted them on the granulating surface, and immobilized them by a strip of lead plaster. Within a few days these transplants grew and proliferated to the margins of the wound The procedure he termed "greffe épidermique" On December 8, 1869, Reverdin made his momentous report before the Société Impériale de Chirurgie (294), in which he described his procedure in detail But so audaciously new was the principle that the operation was regarded with skepticism, and for the time being the significance of the discovery and its possibilities in surgery went unrecognized, among his colleagues he found but two supporters—Guyon, his teacher, and Marc See Fortunately, however, the importance of the procedure was not lost to science, for Pollock (283) of London, learning of Reverdin's discovery, put it into practice in May, 1870, and so spectacular were his results that they immediately aroused the enthusiasm of the medical fraternity of London With the reawakened

interest successful results were soon reported in Ireland and in Scotland (125), and the method was quickly adopted by American surgeons (153, 52) It then spread to Germany where Czerny (64), working in Billroth's clinic, expressed wonder that German publications had so long been silent on this important procedure Subsequently it was enthusiastically accepted in Russia (177, 209) and in Italy (232, 275, 3, 7) In 1872 Reverdin (171) again reported, this time on his experience with fifty personal cases and on the results of other surgeons using this type of graft. By this time he had come to realize the impossibility of cutting a purely epidermic graft, and he accordingly revised his original description, namely, "I raised with the point of a lancet two little grafts of epidermis from the right arm, *taking care not to cut the dermis*"—by stating that the graft also contained *a thin layer of corium*

As experience grew, much information regarding these grafts was accumulated by various surgeons Ehrenfried (96) summarizes their findings "There was a well defined limit to the proliferative power (Dobson) [87], that, accordingly, multiple grafts were advantageous (Dobson) [87] and would give a firmer and more rapidly forming cicatrix (Steele) [320], that grafting on a bleeding surface was usually unsuccessful (Mason) [235, 234], but that with hemostasis grafts took well on fresh surfaces as after the amputation of a breast (Heath) [155], that grafts might be transplanted successfully on syphilitic ulcers (Clark) [53] , that the papillary layer was the essential element (Steele) [320] (Page) [265, 266] , that epithelium will grow most rapidly in the direction in which it will have the least distance to cover before reaching other growing epithelium (August Reverdin) [292]" The chief objections to Reverdin's method were as pointed out by Thiersch (338) in 1874, that healing was slow, that the new tissue was but little more than a cicatrix, that it was not adaptable to weight bearing surfaces, that it was subject to contraction, and that the result was unsightly In an endeavor to overcome these disadvantages, Thiersch (337) elaborated a wholly different technic from that of Reverdin by covering the entire wound with large strips of epidermis after the granulations had been removed. At the fifteenth Kongress der deutschen Gesellschaft für Chirurgie in 1886 he reported his results with this type of graft. The procedure was immediately adopted and has since come to be known as the "Thiersch method of grafting" Priority for the discovery, however, should be credited to Ollier (258) (fig 55) who in 1872 wrote "Instead of grafting small bits of epidermis 2, 3 and 4 mm. square, as M. Reverdin does, I use large grafts, 4, 6 and 8 cm. square and more, including not only the superficial layers of the skin but part of the derma.' The use of these grafts proved to be a distinct advance over Reverdin's small grafts inasmuch as the method was simple, easy and rapid, large areas could be covered in one operation, and the single transfer lessened the danger of infection, and until the introduction of the split-skin graft by Blair (26) in 1929, it is probable that this type of graft enjoyed a greater popularity and served a broader field of usefulness than had any other Shortly after the introduction of the method, however, clinical experience demonstrated that it had many of the drawbacks of Reverdin's method, i e. the epithelial cover did not prevent contraction, it was not adaptable to wear, slight pressure caused it to ulcerate or slough, and it was prone to undergo discoloration.

The general dissatisfaction led to the revival of the second Indian method of full thickness skin grafting in 1875 by Wolfe (363) (fig 56) of Glasgow, who used it successfully in the reconstruction of a lower eyelid In 1893, at the twenty-second Kongress

FIG 54

FIG 55

FIG. 56

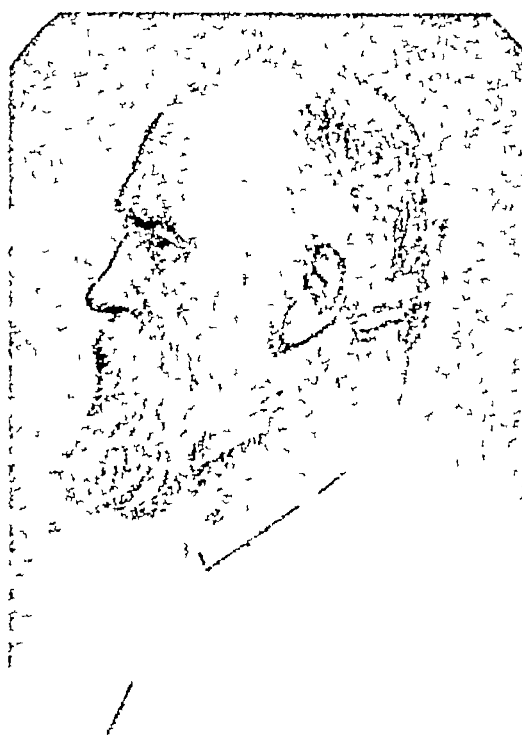

FIG 54 Jacques-Louis Reverdin (1842- [illegible]
FIG 55 Louis Xavier Edouard Léopold Ollier [illegible]
FIG 56 John Reissberg Wolfe (1824– [illegible]
FIG 57 Fedor Krause (1857–1937)

der deutschen Gesellschaft für Chirurgie, Krause (194) (fig 57) of Altona reported his results following the use of this graft in general surgery and described an improved technic which is practically the same as that employed today While the full thickness graft of Wolfe-Krause overcame many of the shortcomings of the Ollier Thiersch graft in that it more nearly duplicated the lost skin in color, texture, and pliability contracted less, and provided a soft, elastic, freely movable cover moderately resistant to pressure, it too was found to possess definite objectionable features. Its thickness reduced its viability and thus limited its use to sterile operative wounds. It was susceptible to infection, demanded exacting care in its application and good healing qualities on the part of the patient, it was not suitable for losses requiring more than skin, and it could not be used in areas incapable of immobilization.

The realization of the limitations of this graft gave a new impetus to the use of the old Indian and Italian flap operation (p 96) Maas' (218) description in 1884 of the technic, indications, and possibilities was so clear that it immediately created a widespread appreciation of the importance of the method Maas pointed out that the flap which carries its own blood supply, unlike the free transplant which is solely dependent for nutrition upon its bed, is more certain to 'take, resist infection, and undergo rapid healing with a minimum of contraction Unlike the graft, it has less tendency to discoloration, and the skin is more resistant, elastic, and movable because of the pad of subcutaneous fat which it can be made to carry These qualities make it a particularly fitting substitute for lost tissues over surfaces exposed to weight bearing and friction such as the sole of the foot. In addition, the flap may be employed as a vehicle to carry other tissues, such as cartilage and bone, whereas a graft cannot provide the nutrition necessary for such a transfer Up to the time of the World War there were but few modifications of the original flap method According to Ehrenfried (96), ' 'Wanderlappen,' flaps carried to inaccessible places by attaching them first to a slit in the skin somewhere between the original source and their final resting place have been used successfully by Israel [175] and Hahn [150] (1887), von Hacker [147 148] (1888 1904) Stenthal [322] (1904), and Hagen [149] (1905) Keetley [181 182 183] (1887 1902) exchanged flaps between face and arm in treating a mole in an infant. Von Hacker [145] (1888) and Croft [60] (1889) rehabilitated the original tagliacotian method under the name of 'bridge graft.' The confinement of a finger hand, or limb in a pocket of skin on the abdomen, thigh or back was practiced by Ollier [256 258] (1872) North [255] (1886), von Hacker [146] (1886) and Schroeder [307], after Fenger (1900) Gersuny [124] (1887) turned a flap from the neck into the mouth on a pedicle of subcutaneous tissue. Greenough [141] of Boston (1903) practiced immediate skin sliding to close the wound left by the flap and Stone [327] of Boston (1905), after Greenough's suggestion, dissected out at a secondary operation a pad of fat left under a flap on the palm. Otherwise the teachings of Maas and Wagner are still followed.

It would seem that with the development of anesthesia and aseptic surgery, tissue transplantation should have made rapid strides but strangely enough, it remained for many years thereafter a resource of decided value to only a small group of surgeons. But with the advent of the World War, the concentration of such a vast number of patients demanding repair afforded greater opportunities than ever before for the study of the behavior of transplanted tissue, and as a result faulty concepts were corrected and the existing methods improved, simplified, and standardized, the field of tissue

transplantation being thus expanded and made available to a greater number of surgeons With the War ended, the mounting employment of machinery in industry, the high speed automobile and aeroplane transportation, together with the increased participation of our people in active sports, provided injuries as numerous and as grave as those of the War and continued the demand for tissue transplantation

Today the art has reached a high level of efficiency and marks a splendid epoch in the evolution of modern surgery Whereas free tissue transplantation in its early history was limited to the resurfacing of fresh wounds and granulating areas, its scope has now been extended to include the implantation of other tissues, such as cartilage, bone, periosteum, nerves, and cornea The function of paralyzed limbs is being restored by the transplantation of muscles and tendons Missing fingers are being replaced by autoplastic transplantation of toes With the success obtained by Alexis Carrel and Colonel Lindbergh (48) in maintaining the vitality of human organs in vitro, new possibilities are opened up in functional reconstruction In the words of Carrel "We can perhaps dream of removing diseased organs from the body and placing them in the Lindbergh pump as patients are placed in a hospital Then they could be treated far more energetically than within the organism, and if cured replanted in the patient A thyroid extirpated in the course of an operation for Basedow's disease, a kidney removed for tuberculosis, or a leg amputated for osteo-sarcoma, would possibly heal under the influence of an artificial medium when living in vitro The replantation would offer no difficulty as surgical techniques for the sutures of blood vessels and the transplantation of organs and limbs were developed long ago " The use of flaps has been extended in the past few years to the treatment of lymphedema praecox (135, 6) and of certain hitherto incurable and fatal diseases For instance, the ischemic heart of coronary disease has been furnished with a new source of blood supply by suturing to it well vascularized flaps taken from the pectoral muscle and the omentum, the collateral circulation thus induced bringing the heart into direct contact with the extracardiac vascular bed (17, 261) While the operation has many objectionable features, to be cited later, and sufficient time has not yet elapsed to properly evaluate its efficacy, nevertheless its immediate results are sufficiently encouraging to give hope that its principles and scope will be widened to include other incurable and fatal diseases

Perhaps the most outstanding advances in tissue transplantation during the past two decades have been the introduction of the small deep graft by Davis (72), the development of the tubed flap by Filatov (109) and Gillies (133) independently, whereby a better blood supply to the flap is assured and the use of longer and larger flaps is permitted, Esser's inlay method of grafting areas heretofore inaccessible, and various technical devices which have made possible the cutting of larger grafts of a more uniform thickness Other contributors who have added luster to the science will be mentioned throughout the text

GRAFTS

Biologic Considerations

The genetic compatibility between the host and the transplant has much to do with the success or failure of tissue grafting The nearer the biologic relationship, the greater the likelihood that the graft will survive On this basis transplants may be

classified as (1) autogenous transplants (autografts), portions of tissue completely separated from their original site and implanted into another location in the same individual, and (2) heterogenous transplants, grafts taken from sources other than the patient himself The latter, in turn, are further subdivided into (a) homogenous grafts (homografts or isografts), tissues taken from the body of another animal of the same species, as from man to man, and (b) zoögrafts, tissues taken from animals of different species.

Autogenous Transplants

The autogenous tissues best adapted for grafting are those which normally depend upon lymph rather than blood for their nutrition, for instance, non specialized epithelial tissue, such as epidermis and cornea, and low-grade connective tissue, such as cartilage and bone. When such tissue is transplanted, there is no immediate need for a readjustment of the arterial and venous circulation, as the graft is capable of absorbing enough plasma from its bed through the power of imbibition to keep the cells viable until it becomes established in its new location. Structures nourished by blood, such as full thickness skin, on the other hand, when transplanted, must survive without a blood supply until the circulation in their new location becomes re-established. Meanwhile the viability of the graft is maintained by a sort of parasitic existence through the absorption of plasma, made possible only by an intimate adhesion between the graft and its host. It is for this reason that great care must be taken in the early stages to fully preserve contact between the graft and its host, otherwise, the graft may succumb before the circulation can re-establish itself

There is a difference of opinion regarding the ultimate *fate of grafts* following their transplantation. Some believe that the graft is preserved, becomes revascularized, and grows as an integral part of the host tissue Others hold that the cells of the transplant are absorbed and that only the elastic stroma survives to act as a scaffold for the migration of the living cells of the host. Based on the latter assumption, attempts have been made to hasten the penetration of the capillaries from the host into the graft by recourse to a process of "fixation" by which the cells are immediately destroyed and removed, leaving the framework intact (251) Still others are of the opinion that the entire transplant, interstitial as well as cellular parts, perishes, to be eventually replaced by the host tissue.

Heterogenous Transplants

Heterogenous transplants, with the exception of those composed of avascular tissue, such as epidermis, cartilage, and cornea (135) (p 161), and those between twins developed from the same ovum (263), have lost their position in scientific medicine, inasmuch as all attempts to employ them have met with failure, despite every measure taken to insure their success, such as conformity of blood groups, consanguinity, identity of race, etc. (21, 136 234 2, 115, 250, 26, 126, 343, 224, 243, 168) In this regard McWilliams (242) asserts 'The result will most certainly be nil The success of isografts may be relegated to mythology " There are many cases on record in which a denuded area was grafted partly with the skin of the patient and partly with that of another individual, in such cases the autoplastic grafts were usually suc-

cessful while the foreign grafts invariably failed Many "successful" cases, however, have been recorded from time to time (15, 70, 254, 344, 166, 237), but the results were undoubtedly based on faulty observations they were either reported before time and exposure had tested the resisting powers of the skin, or their success was only apparent In the latter case, especially if the denuded area was small, the transplants may have adhered only temporarily, the epidermis proliferating from the edge of the denuded area to points lying below the graft and covering the wound, thus giving the appearance of grafted epidermis As examples of these claims, Epley (1896) reported a transfer of 52 square inches of skin in 6 large pieces from 5 different persons and 300 smaller grafts from 4 other persons to repair an injury of the foot, all of which were "successful" Fungengel (1895) likewise cited a "successful" case in which he planted grafts from 17 females onto a brewer's thigh, and Ranking (1906) cites a case wherein "the arms, legs and backs of a patient's son, husband, mother-in-law, the local coroner, doctor and three nurses" were called upon to furnish the necessary material for grafting (286) Ashley (8) reports favorable results following the use of heterogenous grafts of circumcised foreskin procured from 7- to 10-day-old infants The grafts were stored for several days in normal salt solution in a refrigerator or embedded in ice cubes

The *cause of failure* in heterogenous transplantation of tissues is unknown Many theories have been advanced In the second half of the nineteenth century Thiersch and Ollier, in the course of investigations, observed that not all tissues were equally successful when transplanted They noticed that autotransplants succeeded best and suggested as a reason that the tissues of different species somehow differed in their chemical composition from one another However, it was not until the twentieth century that intensive study was made regarding the factors which determine the relation between the host and the fate of the transplant Loeb (212) suggests that the biochemical differences in the proteins of different individuals create an antagonism between the protein of the host and that of the graft and explains this phenomenon on the assumption that the tissues of every person contain certain chemical characteristics peculiar to the tissue, which he calls the "individuality differential" These differentials, he believes, determine the reaction between donor and host When a tissue is transplanted heteroplastically, the individuality differential of the graft is not adapted to its host In this inadequate environment the graft develops injurious substances, and it is to these toxins that the host tissue responds, the degree of reaction depending upon the difference in the tissue differentials Even tissues within the same individual may vary in chemical differential, and this may account for the occasional failure of autografts to survive, even though placed under ideal conditions In the words of Loeb (212) "The conclusion that the organismal differentials are due to the genetic constitution of the organisms is based on the correspondence between the characteristics of the differentials and the relative intensity of the reaction against strange differentials on the one hand, and the genetic relationship of the organism, which are the bearers of the differentials, on the other hand" Loeb raises the question as to whether these tissue differentials act as simple toxins on the cells of the host, or whether they are complex toxins and assume their toxic character only after they have previously combined with a constituent of the body fluids of the host The former assumption seems sufficient to explain the experimental findings

Schoene (306) attributed lack of success in heterotransplantation either to the

formation of immune bodies or to athrepsia, which signifies the withdrawal of food from the transplant by competing tissues. According to Ribbert (296) and Ehrlich (97), the reason for unfavorable results in heteroplasty can be referred to biologic differences in the leukocytes of the individuals concerned Eden (95) is of the opinion that failure is due to alterations in the local agglutinative condition of the substratum

Until the reason for failure of heterogenous transplants is definitely known, they will remain in the experimental stage and will have little clinical value, and even should the cause be revealed, there will still be the problem of altering the tissues physically or chemically before transplantation, in such a manner as to prevent the production of substances which call forth antagonistic reactions leading to their failure. Some of the suggestions which have been advanced to meet the latter problem are blood grouping desensitization of the donor by injection of the recipient's blood into the site of the proposed graft, culturing the graft in the recipient's serum and immunizing the donor to the foreign protein by preliminary small transplants. Shawan (312) attempted to apply to tissue transplantation the biologic advances which have been made in the field of homoplastic blood transfusion and agglutination, and suggested the use of transplants from homonymous blood groups He demonstrated that in cases of grafting in which matched donors were used, the graft "took" temporarily but that within a few weeks the epithelial cells degenerated, a cellular infiltration took place followed by fibrosis, and that finally the graft became absorbed, where the blood groups of the donor and the recipient were not homonymous however, the graft degenerated immediately without showing any tendency to "take Kubanyi (196) reports that although in homotransplants of similar blood groups the graft did not become fixed throughout its entire surface but only as islands of tissue, the growth of epidermis, nevertheless was visible from below He states that he was able to cover large areas with grafts taken from donors whose blood corresponded to that of the recipient. Baetzner and Beck (13) in an endeavor to prolong the life of the homograft, injected into the recipient in increasing doses serum and extracts of the tissues of the donor with the idea that in this way antibodies formed against the graft might be turned aside, the antibodies uniting with the serum and the injected extract rather than with the cells of the homograft. Stone, Owings and Gey (324) suggest that the donor's tissue be cultured in the recipient's serum before its transference to the host (343) Others have tried to retard the death of the transplant by employing chemicals. Lehmann and Tammann (202) made use of electrocollargol and Tammann and Patrikolakis (335) employed colloidal copper

Lexer (206) concludes that despite all means taken to preserve the life of heterogenous transplants they invariably perish in about 14 days from dry gangrene, suppuration, or cicatrization, and serve no useful purpose He believes that reports to the contrary are fallacious or are the results of incomplete observation and flatly states that "homografting promises nothing and the trouble and suffering of the donor is without avail."

Homogenous Transplants (Homografts or Isografts) Homogenous transplants, i.e., tissues procured from the body of another person, are usually taken from members of the same family (syngenesioplastic grafts), as from mother to child, or brother to sister This practice is based on the belief that the nearer in the biologic scale the graft, the less foreign the protein and the more likely the "take. Homografts have also been taken from amputated limbs (114, 314, 258, 234, 2) and from cadavers

(58, 176) Although this type of graft, like all heterogenous transplants, ultimately disappears in one way or another, as a rule it adheres and appears to grow for several weeks In six weeks it is usually firm in its place and forms wrinkles when the part is moved, during the seventh week, however, it becomes livid, and the bed of the graft takes on a spongy appearance About the eighth week a necrotic process begins at the circumference and extends toward the center of the graft, the epithelium exfoliates, and finally the bed becomes covered with unhealthy granulations

The microscopic changes following transplantation of homogenous grafts differ distinctly from those observed after autogenous grafting As will be seen later (p 112), the transplantation of an autogenous graft is accompanied by a marked proliferation of capillary loops, by the production of fibroblasts which tend to remain well preserved, and by the infiltration of lymphocytes Polynuclear leukocytes, however, are not attracted. Following the transplantation of a homogenous graft, on the other hand, capillary development is less marked, the fibroblasts tend to form connective tissue, and there is a predominance of polynuclear cells which, like a "hostile army," destroy the tissue which is inimical to them Since polynuclear leukocytes are known to appear only in conditions in which there is an acute and intense reaction of the tissues to harmful substances, their predominance around homotransplants would seem to indicate that these tissues produce toxins more injurious than do autotransplants, and this conclusion agrees with laboratory findings

Despite the fact that homogenous grafts ultimately fail, they are often employed to advantage as a temporary measure in patients whose general condition contraindicates the disturbance which would be occasioned by autoplastic grafting In such cases they serve as a mechanical protective covering, reduce the albuminous drain from the raw surface, impede the formation of scar tissue, stimulate healing, and curtail the number of painful dressings Not infrequently the patient's condition is so improved by the time the graft is exfoliated as to permit the replacement of the loss by an autograft.

Like homogenous grafting, the transfer of flaps from person to person has also proven unsuccessful even when done under the most favorable conditions In this connection Gillies (135) describes an interesting experiment

"A boy aged 18 months was presented with severe contracture from the buttock to the sole of the foot on the outer aspect of the right lower limb This condition had occurred as the result of burns There was marked deformity of the hip, contracture of the knee, and the foot was turned completely outwards The mother was willing to submit to operation A flap of skin designed to cover the lower $\frac{3}{4}$ of the defect which would be caused by the excision of the scar was mapped out on the outer side of the mother's right thigh The blood groups of the child and mother were both taken and were found to be suitable The operation was uneventful and easy The child's foot was in juxtaposition to the mother's buttock, and the child's head to the mother's foot The flap being very short across as compared with the width of its base, it was perfectly safe to embed almost the whole of the flap at the first operation The healing was by first intention of all suture lines The stitches were removed in ten days A normal looking scar developed and in addition to the edge union the body of the flap had united to the raw area made on the child's limb It was so firm that the child could almost have been lifted with the mother's leg At the second operation three weeks later for partial division of the pedicle healing was

not quite so satisfactory but nothing untoward occurred. At the third operation for final division of the pedicle which consisted of bedding about 3 mm. of unattached skin—an absolutely safe procedure in an autologous graft—it was observed that the whole of the donor flap became completely white, and that although it was adherent everywhere except for a tiny edge no blood supply from the recipient appeared to go into it. It remained white and sloughed completely in three days. At the time of the operation a biopsy was made taking a piece of skin on either side of the normal looking joining scar, and including a portion of the scar. Section showed blood vessels going up to the scar but failing to penetrate the donor skin.

"In conclusion it would appear that in this apparently successful case although all the signs of repair were present there was complete refusal of the recipient's blood vessels to enter the donor skin. Cartilage and cornea would appear to be the only two substances which can be successfully used as homologous grafts, and as neither of these substances depend on the presence of blood vessels for their nutriment it would appear that other tissues of the body requiring blood vessels cannot as yet be grafted from one patient to another."

In transplanting tissue from man to man the danger of transmitting disease, particularly syphilis (176) and tuberculosis (64, 65), must be kept in mind.

Zoögenous Transplants. Experimental transplantation of tissues from animal to man has been practiced since the dawn of surgery (268, 221, 41, 84). John Hunter (173) in the eighteenth century speaks of zoögenous grafting as "common and well known." It is interesting to note that in the seventeenth century the Church held implantation of tissue from a beast into the human body to be "marring God's image of man" (221). Obviously, if this type of graft were successful, it would supplant all other forms, for it would do away with the pain and scarring of autoplastic transplantation and make available an unlimited supply of material. But unfortunately, as is the case with all heterografts, failure is inevitable.

Skin Grafts

Skin grafting is a therapeutic measure of the greatest utility for the replacement of surface losses, even though the wound, if left to itself, may heal spontaneously, since the resultant scar has no semblance to normal skin, is devoid of hair and glands, is easily traumatized, subject to infection and recurrent ulcerations and is not adapted to weight bearing. Should spontaneous healing fail to take place, the wound is left exposed to infection and septic absorption; the albuminous drain leads to anemia and exhaustion, and the slow healing results in contraction, deformity, and impairment of function consequent upon the conversion of exuberant granulations into fibrous tissue. In such cases, resurfacing by means of skin grafts promotes rapid and sound healing, minimizes the danger of infection and the degree of contraction, shortens the period of disability, reduces the number of painful dressings, and cuts the cost of hospitalization. It is gratifying indeed to observe how quickly the temperature drops and the patient's condition improves after the area has been covered with healthy skin.

Skin grafting finds its greatest applicability (1) in the correction of congenital defects, (2) for the relief of acquired deformities causing impairment of function—for instance, in the case of ectropion, in which the contracted lid exposes the eye to irritation, (3) in the replacement of degenerated tissues—as in the case of certain skin

affections, such as irradiation dermatitis, chronic ulceration, and lupus, which frequently respond favorably to excision followed by immediate skin grafting, after they have proved refractory to all other forms of therapy, and (4) in the substitution of mucous membrane linings, such as that of the orbital cavity, nose, mouth, esophagus, bladder, and urethra

Anatomic Considerations

The principal distinguishing feature of the various types of skin grafts is the level at which they are cut (fig 59), therefore, in order to approach adequately the problem of skin grafting, a brief review of certain anatomic points is essential

The skin covers the surface of the body and is continuous with the mucous membrane at the various orifices In the average adult it has a superficial area of 10,000 to 18,000 square cm Its thickness varies from 1 5 to 5 mm, depending upon the location, age, sex, race, and state of nutrition It is thinnest on the eyelids, penis, and labia minora, and thickest on the palms, soles of the feet, shoulders, and back

The skin is composed of two layers (1) the epidermis, cuticle, or scarf-skin, and (2) the dermis, cutis, corium, or true skin The *epidermis* is perforated by skin glands and hair, is non-vascular—receiving its nutrition from plasma derived from the dermal vessels—and is composed of five layers in areas of average thickness, and of three layers where the skin is very thin The lowest layer is the stratum germinativum (basal cell layer) This layer lies in contact with the papillae of the dermis and consists of actively growing columnar epithelial cells resting on a basement membrane which serves to separate it from the dermis As these cells multiply they are extruded toward the surface, and in the course of the process undergo keratinization It is in this basal layer that the pigment of the skin is found Above the stratum germinativum are several layers of epithelial cells, of which the most superficial is the stratum corneum composed of several layers of flattened squamous cells These layers are constantly being cast off and replaced by cells from the deeper layers The *dermis* forms the deeper layer of the skin and constitutes its real foundation It varies in thickness from 1 to 2 mm and consists of three layers The outer layer (pars papillaris) projects into the epidermis as papillae which terminate in single or multiple points, some of which carry vascular loops, others nerve endings This layer is composed of white fibrous and yellow elastic tissue In the peripheral portion are the dermal chromatophores (colored cell plastids), connective tissue cells which by phagocytosis have absorbed melanin produced by the epidermal cells and have thus become pigment carriers The middle layer (pars reticularis, "leather of the skin") fuses with the subcutaneous tissue and is composed of coarse, loosely arranged, white and yellow elastic fibrils which run parallel to Langer's lines on the surface of the skin (figs 19–22) In this layer are found the coils of the sweat glands The inner or subcutaneous layer is a loose network of connective tissue which serves as a buffer against external violence and provides a bed for the larger blood vessels, the lymphatics, and the nerves of the skin, as it does also for the deeper hair follicles and both the sweat glands and the sebaceous glands Its meshes are filled with fat which helps to give fulness and roundness to the body outlines

The *appendages of the skin* comprise the sudoriferous glands, sebaceous glands, and

hair follicles, and it is from these structures that regeneration of epithelium takes place after razor grafts have been cut. The sudoriferous glands are coiled tubular glands, the fundi of which lie in the corium, from there the ducts run in a spiral course to the surface of the skin where they open in the sweat pores. Irritating substances in the blood stream eliminated in the sweat through these glands may interfere with the "taking" of a graft. The sebaceous glands are simple or branched alveolar glands lying in the corium in relation to the hair follicles and are situated principally at mucocutaneous junctions. They evacuate their contents into the hair follicles and on the surface of the skin.

The *blood vessels of the skin* (fig 58) lie in the dermis and vary in size and number in different parts of the body, being most numerous in areas subject to external pres-

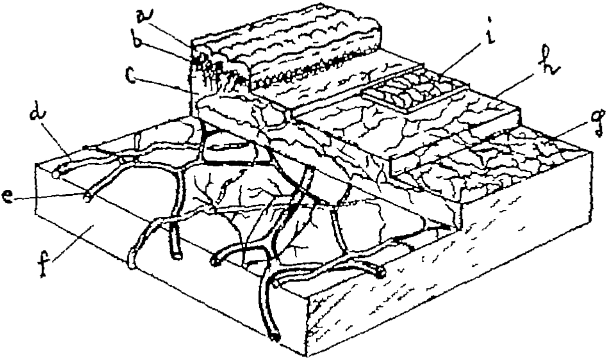

FIG. 58. Diagrammatic representation of blood supply of skin. *a* epidermis. *b* papillary layer *c* tunica propria. *d*, cutaneous arterial network. *e*, venous network. *f*, subcutaneous layer *g*, venous network. *h*, subpapillary arterial network. *i* venous network. (Redrawn from Spalteholz)

sure, such as the gluteal region. In the deepest layer of the dermis they anastomose freely with one another to form a network, from here they proceed upward to form a second subpapillary network at the junction of the middle and outer layers of the skin, from this network numerous vessels run as terminal arterioles to the superficial layer of the skin where they turn at right angles to take a course parallel to the surface. The venous blood is returned by several networks, the first lying beneath the base of the papillae and receiving blood from the superficial venous capillaries This subpapillary network enters into a second venous network, the two communicating by short venules (318)

The *nerves of the skin* reach the lowest level of the epithelium in the form of bundles, as they ascend, they lose their medullary sheaths and appear as naked axis cylinders which break up into fine branches to form the tactile corpuscles

Histologic Changes Following Transplantation of Skin

The early changes which take place after the transplantation of a graft are similar to those in the healing of a clean wound. The stages may be divided as follows. (1) *Stage of Plasmic Circulation* (137). This stage lasts from 24 to 48 hours. Within a few minutes after transplantation the blood vessels of the host in contact with the graft dilate, the dilatation being followed by an exudation of plasma (75). The plasma soon becomes converted into fibrin which not only serves to anchor the graft to its bed, but also forms a matrix for the plasma and lymph circulation and a scaffolding for the budding endothelial cells of the blood vessels destined to nourish the graft. There is also an extravasation of leukocytes which work their way into the interstices and empty capillaries of the graft. At the same time, fibrocytes infiltrate the graft and convert the connective tissue into collagen. (2) *Stage of Vascularization*. In the course of 18 hours delicate vessels in the form of endothelial tubes arise from the capillary loops of the host and force their way into the graft, sometimes joining directly with the severed capillaries of the latter (102). Davis and Traut (75) found that when the latter vessels were collapsed, the cells and lymph could not enter the implant, and there resulted an interference with nutrition. It is for this reason that full thickness grafts should be removed with a knife instead of with scissors which by their pinching effect close the vessels. It also explains why these grafts should be sutured to the host under normal tension so that the mouths of the capillaries may remain open to receive the newly formed vessels (122). About the second or third day the capillary loops from the host penetrate the deeper part of the implant, and the graft itself begins to take an active part in the process, as manifested by a marked proliferation of epithelium from the germinal cells, the hair follicles, and the dermal glands. In time the fibrous and elastic tissues of the graft are replaced by new-formed tissue developing from the pre-existing elements. (3) *Stage of Organic Union*. This stage begins on the fourth or fifth day, when the layer of leukocytes between the graft and the host is replaced by a layer of fibroblasts. An adequate blood supply appears to be present after the eighth day, as shown by a pinkish color in the graft. By the tenth day permanent organic union is complete. During this stage a delicate subcutaneous connective tissue rapidly forms and binds the graft more firmly in place. It is this connective tissue which is responsible for subsequent contraction of the graft. Fourteen to twenty days after implantation the graft assumes its normal appearance.

Nerves begin to grow into the graft from the surrounding tissues about the fifth week, but innervation remains imperfect for several months, and in large grafts may not be complete for a year. The return of sensation begins at the proximal and lateral borders of the graft and spreads progressively over its surface. The time of its appearance, according to detailed studies of nerve regeneration in skin grafts by Kredel and Evans (195), Davis and Kitlowski (74), and Davis (70), is in direct ratio to the thickness of the transplant, thus sensation returns earlier in a flap than in a graft. Recently, however, McCarroll (240) has obtained results quite different from those of previous investigators. He found that in thick razor grafts regeneration occurred over all parts of the graft simultaneously and that the rate of the return of sensation was inversely proportional to the thickness of the graft.

In time a thin layer of *fat* develops beneath the graft which renders the skin more or less mobile so that it can be picked up in folds. The normal resisting power of the

graft, however, is not attained for several weeks, even after a complete "take", therefore it is necessary to provide adequate protection during this period.

Late Changes Following Skin Transplantation

Unfortunately, even the most successful transplant is subject to certain subsequent changes which may have a detrimental effect on the final result, for this reason it is especially important that these possibilities be carefully considered before a decision is made to graft, particularly on an exposed surface.

The final *color* of transplanted skin cannot be definitely foretold, and on exposed areas this uncertainty constitutes the greatest drawback to grafting While grafts ordinarily tend to assume the color of their surroundings, they not infrequently become pigmented and stand out as patches varying in color from a pale brown to that of prune juice The pigmentation may be evenly distributed throughout the graft, or it may assume an irregular blotchy character Occasionally it disappears entirely and the graft stands out as a dry, white, shiny area in contrast to the surrounding skin. In such a case the color can often be toned down to match that of the surrounding skin by tattooing or by exposing the part to ultraviolet rays. The cause of the variation in color is unknown It is thought by some to be due either to a disturbance in migration of chromatophore melanin cells from the prickle cell layer or to a disturbance of the sympathetic motor innervation of the capillaries. Generally speaking, full thickness grafts are not as likely to change color as are thinner grafts If the superficial epithelium is lost the pigmentation is likely to be deeper than if the graft had "taken" without surface blistering In individuals of light complexion grafts show less tendency to undergo pigmentation than in those with darker skin.

Some *contraction* beneath the graft is inevitable, the degree varying with the thickness of the graft, the location of the recipient area, and the completeness of the "take" As a rule, the thicker the graft the less will be the amount of subsequent contraction In full thickness grafts it does not ordinarily exceed 10 per cent, provided the surrounding tissues are inelastic and the graft "takes" perfectly, however where there is more than a superficial loss of epithelium, or where the surrounding tissues are elastic, as in the neck, it may contract 30 per cent or even more. Razor grafts, even under ideal conditions, will shrink to as much as 50 per cent of their original size. This contraction is not the fault of the graft itself, which is composed principally of epithelium with very little elastic tissue, but is due rather to the cicatrization of the base upon which it is placed. Despite the fact that considerable shrinkage is inevitable in razor grafts, the increase in the rate of healing which they occasion will cause less ultimate contraction than if the wound were allowed to heal unaided. If function is to be preserved the possibility of shrinkage should be taken into consideration when laying the grafts. In certain localities shrinkage can be compensated for by doubling back the skin bordering the defect (fig 82)

Occasionally a heavy *scar* will form along the line of junction between the graft and its host. This is more likely to occur in full thickness grafts than in razor grafts, and children are more subject to such disfigurements than are adults. The intelligent use of radium and x ray therapy is often helpful in reducing these scars (p 1372)

Vesicle and bullae formation on the surface of the graft is a common occurrence and frequently these formations are so extensive as to suggest the death of the graft.

It is advisable not to draw hasty conclusions from such cases, as a good part of the graft frequently survives, regeneration of epithelium taking place from the glands and hair follicles

Finally, despite every precaution, the graft in whole or in part may undergo *necrosis*

Classification of Skin Grafts

Skin grafts are classified anatomically as follows (fig 59):

(A) Thin Razor Grafts

(1) Small thin razor graft (Reverdin)

(2) Large thin razor graft (Ollier-Thiersch)

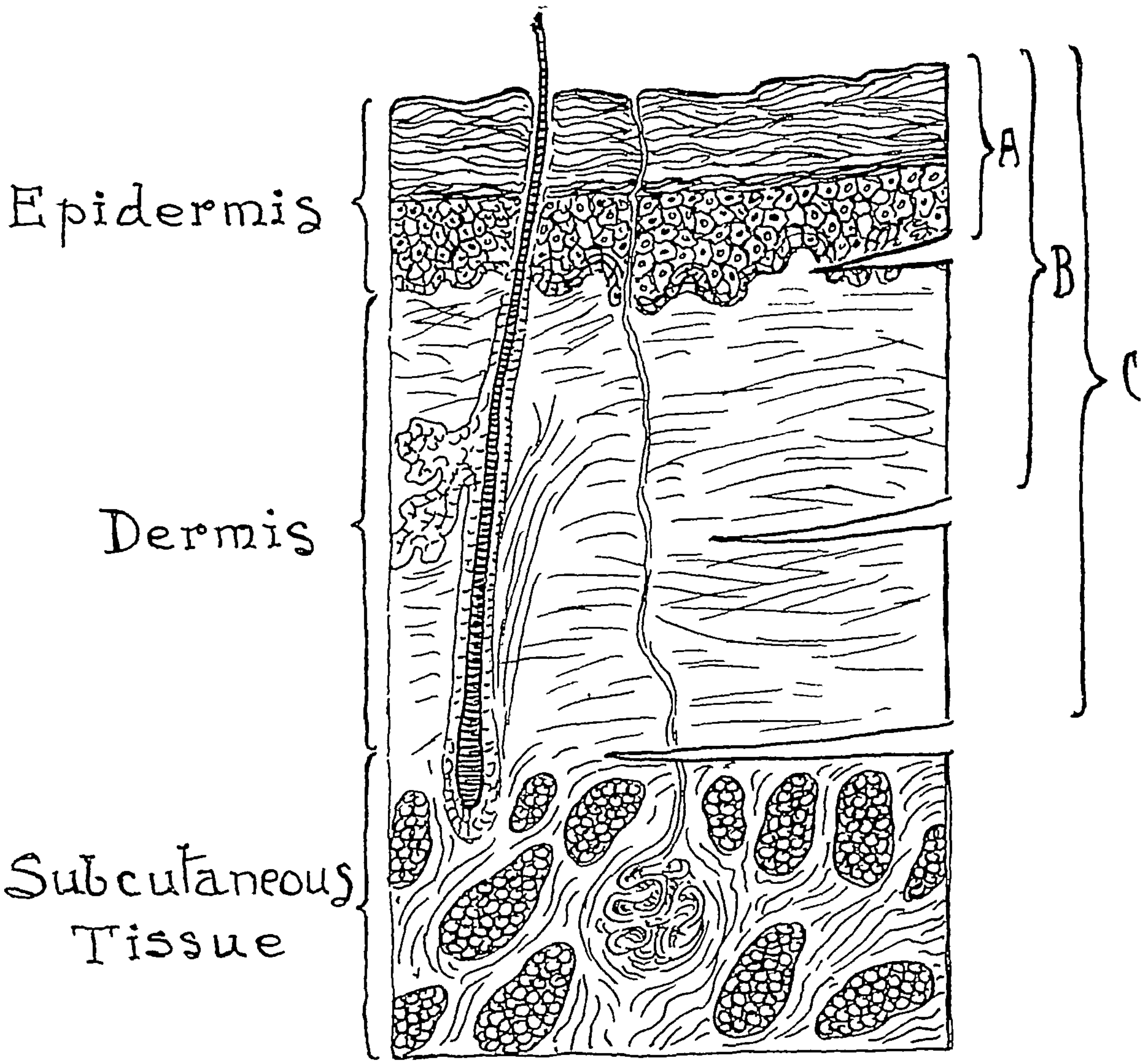

FIG 59 Sectional view of skin, showing level at which grafts are cut *A*, thin razor grafts *B*, split-skin grafts *C*, fully dissected skin grafts

(B) Thick Razor Grafts (Blair's split-skin or intermediate skin grafts)

(C) Fully Dissected Skin Grafts

(1) Small deep graft (Davis)

(2) Large full thickness graft (Wolfe-Krause)

The term *small thin razor graft* is used to designate a graft composed of the full thickness of the epidermis and the most superficial layer of the dermis (fig 64) These grafts are cut in discrete morsels averaging 4 to 5 mm in diameter *Large thin razor grafts* are composed of sheets of epidermis including the tops of the papillae of the dermal layer and have the appearance of thin tissue paper (fig 59) *Thick razor grafts* are composed of epidermis and $\frac{1}{3}$ to $\frac{3}{4}$ of the thickness of the corium (fig 59) *Small deep grafts* are cone-shaped sections of skin 0 4 to 0.5 cm. in diameter, they consist of the entire thickness of the skin in their central portion and taper off toward the periphery so as to include only the epidermis (fig 83) *Large full thickness grafts* comprise the whole thickness of the skin (fig 59)

General Considerations

In order to present adequately the subject of skin grafting, it is necessary to consider it first in a broad perspective Although some of the general observations are later repeated under the individual types of grafts, such repetition will help to emphasize their importance.

Once the indication for grafting is defined, cognizance must be taken of a number of factors if the operation is to be successful, namely, the potential healing qualities of the patient, the bacterial condition of the area to be grafted, the resistance of the base, and the nature of the tissue lost.

Potential Healing Qualities of Patient. The potential healing qualities of the patient are determined largely by the age and the general physical condition, these factors are discussed in detail in Chapter VIII. Generally speaking, the younger the patient, the more certain is the graft to 'take" and the more natural will be its ultimate appearance although with proper care grafting can often be successfully carried out in individuals well advanced in years, even on unfavorable surfaces, as in the case of ulcers of the leg General disorders, such as syphilis, diabetes, nephritis, rickets, anemia, malnutrition, blood diseases, and acute infections—indeed, all constitutional faults—tend to interfere with the success of grafts and should be corrected, if possible, before any grafting operation is undertaken It is gratifying indeed to see unhealthy, pale, indolent granulations assume a normal healthy color as soon as the general nutrition of the patient improves. Local infections even in parts of the body remote from the operative site, also point to the fact that the patient's resistance to infection is low at the particular time, and contraindicate skin-grafting operations. There are occasions, however, when the general condition becomes subservient to the immediate need, for instance, following extensive cutaneous burns where the albuminous drain and septic absorption from the large raw surface menace life. In such cases, even though conditions for grafting are not ideal, it may still be good judgment to graft with the risk of failure or of partial success only, rather than chance the consequences that may arise from neglect of such a raw surface When the patient's general condition is so poor as to contraindicate the disturbance occasioned by the application of autogenous grafts, homogenous transplants may frequently be resorted to with advantage. Despite their ultimate failure they serve to give the patient a respite from the disastrous effects of septic absorption, and frequently his general condition is so improved by the time of their disappearance that an autograft may be used.

Preoperative Preparation of Bed for Reception of Graft

It is scarcely necessary to mention the fact that the healthier the recipient area at the time of grafting, the more likelihood there is of the ultimate success of the graft In the absence of infection all grafts "take" well when placed on well vascularized adipose tissue, fresh muscle, periosteum, perichondrium, and tendon sheaths, in the order named They are less likely to be successful, however, on a bed of non-vascularized fat, fascia, and tendons stripped of their sheaths, and will not "take" on bone devoid of periosteum

If the surface upon which the graft is to be placed is aseptic—for instance, following the removal of tissue in a clean operation or in a clean accidental wound seen within 6 to 8 hours after injury—it can be mechanically cleansed and, after complete hemostasis, immediately skin-grafted But if the bed is infected or is covered with sluggish granulations of a dark red lusterless appearance, which bleed easily and give rise to a grayish mucopurulent discharge, all thoughts of grafting must be abandoned until infection has been controlled and the granulations made healthy. Completely satisfactory means by which this can be accomplished are still an objective to be hoped for. The numerous methods suggested attest in themselves the inefficacy of any single plan Nevertheless, with care, infection can be reduced and the granulations made sufficiently healthy in 2 or 3 weeks to warrant the application of a graft The means employed are essentially the same as those for the treatment of an infected wound and are discussed in the section dealing with that subject Generally speaking, the aim is (1) to rid the granulating area of purulent exudates and necrotic tissue; (2) to limit bacterial growth; and (3) to intensify the defensive reaction of the tissues

The readiness of the area for grafting is judged by its gross appearance rather than by bacterial culture, since it is doubtful whether a granulating surface of any size is ever free of contamination As soon as there is a cessation of discharge, a disappearance of the marginal inflammation, and the formation of clean, firm, flat granulations of a rose pink color, all antiseptic dressings are discontinued and replaced by compresses of normal salt solution applied at regular intervals for 48 hours before operation, care being taken to avoid maceration of the granulations by too great a frequency of applications In the case of extensive raw surfaces it often happens that only a part of the granulating area is sufficiently healthy for grafting. Under such circumstances it is advisable to graft the healthy areas at once and leave the balance for a later date, when conditions have become more favorable

On the night before the operation, the granulations are douched with ether and covered with a wet compress. This is left to dry out and is carefully soaked off with normal salt solution at the time of operation

Operative Considerations

Before the operation, a history should be taken and a physical and laboratory examination made to determine the presence of any general or local factor which may have an adverse bearing on the outcome The details of these examinations are discussed in the section dealing with the operative risk As in all surgical procedures, it is imperative to have clearly in mind a picture of the final results to be achieved, and this consideration necessitates careful diagnosis and planning The extent of the area to be grafted must be calculated, the source of donor material selected, the loca-

tion of ultimate scars considered, and the steps of the repair clearly mapped out with the aid of photographs and plaster casts. Irrespective of the type of graft and of the method of application, an aseptic and an atraumatic technic will make for the highest percentage of successes. In many cases even trifling injury, such as the touch of an instrument or pressure with gauze, may so damage the graft as to interfere with its survival. For details of the general technic the reader is referred to Chapter I.

Instruments The basic equipment for all grafting operations consists of (fig 60) Two Bard Parker knives, #10 and #15, 3 single and 3 double dural hooks, 2 straight and 2 curved scissors, 2 dissecting forceps, 2 probes, a flat spatula, horsehair on small curved cutting needles or fine waxed silk on eyeless needles, 12 mosquito forceps for measuring a metal tape and a compass, for local anesthesia, a 10 cc. Luer syringe

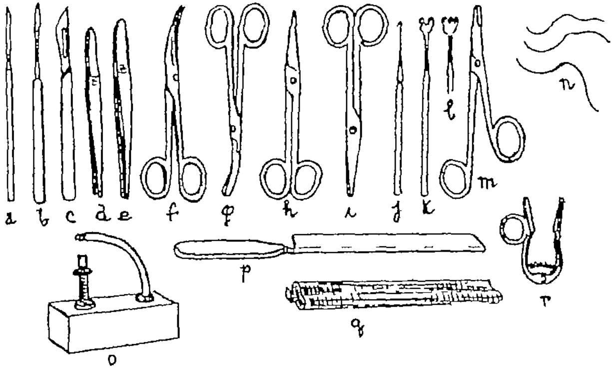

FIG. 60 Skin-grafting instrumentarium. *a–c*, knives *d–e*, dissecting forceps, *f* curved sharp-pointed scissors *g* curved blunt-pointed scissors *h*, straight sharp-pointed scissors *i* straight blunt-pointed scissors *j* single-pronged retractor *k* double-pronged retractor *l* rake skin retractor *m*, needle holder *n*, atraumatic needles *o* Blair's suction box *p* Blair's skin-graft knife *q* protective guard for knife, *r* small needle holder

with long and short needles, for dressing, oiled silk, xeroform gauze, silver foil, and several blocks of stent.

For cutting *small thin and small deep grafts* the special instruments required are straight round intestinal needles #50 and blunt nosed hemostats with which to hold them.

For *large thin and large thick razor grafts* (A) the instruments required for cutting the graft are (1) A Blair knife, a light razor-ground knife with a blade 18 cm. long and 2 cm. wide, set in a stiff back and supplied with a metal sheath (fig 60-p,q) The knife can be stropped before use on a folded towel covered with a thin layer of sterilized emery flour (2) A barber's razor with a rounded heel and toe for small grafts. (B) Contrivances for putting the skin under tension are of several varieties. The most useful is (1) Blair's suction box (fig 60-o), described by Blair (26) as follows "These

are hollow brass boxes with the underneath side open for application to, and suction on, the skin Boxes of three different lengths of openings are used—4 5, 7, and 9 5 cm —for application to different areas, the smaller one being especially useful for obtaining grafts from the abdomens of infants and children Just within the opening there is a series of transverse bars which prevent the skin from being drawn bodily up into the box The ends are corrugated for gripping and are 2 5 cm square A tube leads from the top of the box to be connected to a non-collapsible rubber tube connected to a strong suction machine There is a spring valve on top of the box with a screw for the adjustment of the strength of suction The suction usually used is $\frac{1}{2}$ of an atmosphere of negative pressure " (2) Two basswood boards 30 cm long, 7 5 cm wide, and 2 cm thick, with smooth rounded edges (fig 67) In place of the basswood boards, Spaeth (317) advises the use of two small hooks attached to a stout 4-inch chain to hold the skin taut while the graft is being cut One pair of hooks is held by the operator and the other pair by the assistant (3) Kirschner's epidermis elevator (fig 68) "To stretch the skin of the thigh in a transverse direction successfully, Kirschner has devised an apparatus with which the stretched skin forms a wide plane and the point of attack on the skin lies below rather than above its normal level so that the cutting process is not hindered At a distance of from 10 to 15 cm apart, which is somewhat wider than the proposed skin flap, two steel rods with sharp points and removable handles are bored under the skin of the thigh in a distal-to-proximal direction so that the ends protrude from the skin The knee is flexed and hangs over the edge of the table On their sides the rods have slits into which fit the ends of four curved steel bridles about 10 cm long Two of these bridles with chains attached are fitted to the rods as shown in figure 68 and the skin between the rods is markedly stretched by pulling on the chains" (189)

There are many mechanical devices on the market which are designed for the dual purpose of stretching the skin and cutting the graft automatically Obviously, such an instrument, if practicable, would prove a boon to the surgeon but, unfortunately, none of these contrivances is entirely satisfactory, as the personal equation of the operator cannot be entirely ruled out in the cutting of a graft The most promising device is that of Padgett (264)

For *full thickness grafts*, the instruments generally used for incising and closing tissues are all that are required

Anesthesia Grafting operations may be performed under general or local anesthesia For the choice of the anesthetic agent and its mode of application the reader is referred to Chapter VII If local anesthesia is to be employed, direct infiltration is best avoided, as it destroys the anatomic orientation by producing a glossy, edematous field, has a tendency to lower the resistance of the tissues, and predisposes to postoperative oozing These objectionable features can be overcome by field block wherein walls of anesthesia are created at some distance from the operative site, isolating it from its sensory innervation, or by nerve block, wherein the anesthetic solution either is injected directly into the nerve trunk or is deposited in close proximity to it Of the two methods the latter is preferable, as it induces a prolonged analgesia with a minimum of anesthetic agent, and one or two injections suffice to anesthetize a large area

Preparation of Recipient Area. The first step of the operation consists in the preparation of the recipient area in order· (1) to allow time for the control of all

bleeding and oozing (2) to shorten the interval between the securing and placing of the graft, and (3) to estimate more accurately the proper size of the graft—for instance, in cases where a graft is to replace a scar, an idea of the size of the defect can be had only after complete removal of the cicatricial tissue and the resumption by the parts of their normal positions

Fresh Aseptic Base. If the area to be grafted is a freshly denuded surface, such as that which follows the removal of tissue in a clean operation, it requires no special preparation, aside from the care necessary to secure complete hemostasis in order to prevent the formation of hematomata which would interfere with the adherence of the graft to its base. While adequate hemostasis admits of no compromise, nevertheless it must be accomplished without the infliction of unnecessary trauma by prolonged handling of tissues, and without the addition of superfluous foreign material in the form of ligatures. Too many hemostats impair the nutrition of the part, and too many ligatures interfere with the approximation of the graft to its base and may prove as detrimental to its ultimate fate as inadequate hemostasis. Obviously, bleeding from large vessels must be controlled by ligation, but in dealing with smaller vessels in which spontaneous hemostasis is likely to occur, the decision lies between the use of multiple ligatures on the one hand, and on the other hand of leaving the vessels undisturbed and depending upon spontaneous hemostasis and pressure to control the hemorrhage. In some instances, rather than chance the consequences of too many ligatures, it is often profitable to apply pressure to the bleeding surface and delay grafting for a few hours.

The technic of securing hemostasis is described in Chapter I Briefly, both proximal and distal ends of all large bleeding vessels are clamped with fine-pointed hemostats and ligated with fine silk or #000 catgut. All non viable tissue above the knots is excised. Exposed veins traversing the field, even though uninjured, are resected, as they may undergo thrombosis after the graft is placed and thus interfere with its viability Small bleeding vessels may be electrocoagulated with a diathermy needle While this method checks hemorrhage speedily and efficiently it must be used with discretion, since the carbonized tissues left in the wound may act as foreign bodies and impair the life of the graft. Capillary oozing is best controlled by pressure with compresses wrung out of hot saline solution. The pressure should be maintained long enough to allow clots to form in the lumina of the vessels—usually about 5 minutes—after which the compress is gradually peeled off Capillary hemorrhage can also be controlled by hot saline irrigations. The use of vasoconstrictors, such as epinephrin, had best be eschewed. While these drugs succeed in producing a temporary local constriction of the vessels, the subsequent vasoparesis predisposes to postoperative bleeding beneath the graft. Frequently, the application of bits of muscle, fat, or fascia to the bleeding area supplies the thromboplastin necessary for clotting Prior to the application of the graft all extravasated blood is removed either by means of a suction apparatus or by gentle pressure with dry gauze Wiping is to be avoided, not only because it is ineffectual, but also because the friction of the gauze traumatizes the bed for the graft.

Contaminated Base. If the raw area is contaminated, as for instance in the case of an accidental wound seen within 6 to 8 hours following injury, it must be mechanically cleansed and surgically excised or débrided before the application of the graft. The details of these procedures are given in Chapter III. Briefly, the wound is covered

with a sterile dressing and the skin adjacent to it thoroughly cleansed, after which the dressing is removed and the wound itself attended to. When practicable, the wound is excised en masse and the graft applied immediately, and thus a compound injury converted into a simple one If excision would entail damage to important structures, the wound may, in many cases, be rendered sufficiently aseptic for the immediate reception of a graft by careful débridement If doubt exists as to the adequacy of the cleansing, if hemostasis is unobtainable, or if necrosis is anticipated because of extensive contusions, the benefits to be derived from early skin-grafting may still be obtained by packing the wound with sterile xeroform gauze If at the end of 24 hours the appearance of the wound and the constitutional symptoms indicate the absence of infection, the gauze is removed, the area cleansed, and the skin grafting is proceeded with

Healthy Granulating Base When the surface to be grafted is covered with healthy granulations, the parts are cleansed and draped in the usual manner With a sharp scalpel the granulating area is circumscribed by an incision well outside the scarred margins so as to give a definite sharp outline to the area and thereby limit the extent of subsequent scarring between the margin of the graft and that of the wound With a sharp knife or razor the soft granulations are then sliced down to a level capable of furnishing adequate nutrition for the graft (fig 65) If the granulations are allowed to remain, they are likely to give rise to exudations, which may interfere with the apposition of the graft to its bed, and are subject to contraction In this relation Ehrenfried (96) notes Thiersch's observation that "the maximum of contraction of the granulation tissue was not attained until the area was covered with epidermis If this process is a long-continued one, the contraction having gone on as far as the laxity of the tissues permit, and the capacity for developing new epidermic cells by the margins having been exhausted, the granulation tissue of the newly covered portions and the deep-lying or primitive granulation tissue of the central uncovered area will have undergone its natural progressive change into connective tissue, while the exposed superficial granulations of the unhealed central portion have remained stationary, few, if any, of their component cells having undergone development into connective tissue. Accordingly, in the unhealed portion of a long-standing ulcer two layers may be made out, the more superficial, of recent granulations, possessing vertically disposed capillaries, and the deeper, more or less fully advanced in its stage of conversion into cicatricial connective tissue, containing a horizontal network of vessels, from which the former spring Thiersch stated that if the upper layer of soft granulations, still capable of contraction and easily excited to exudation, be removed, and the grafts planted directly upon the denser substratum, they would become firmly adherent without the risk of being separated by exudation and undisturbed by further cicatricial contraction He also advised the trimming away of the margin of the wound, especially if the edges were indurated, or the newly formed epithelium was of unhealthy appearance"

The excision of the granulations usually occasions profuse hemorrhage and must, therefore, be done with care Bleeding is best controlled by pressure with hot saline compresses If the area is extensive, it is a good plan to remove it in sections by gridironing it into squares of from 2 to 3 cm When one square has been removed, hemorrhage from the raw area is controlled by pressure while another square is being denuded If in spite of all precautions the loss of blood has been considerable, a blood

transfusion should be administered. Should the general condition of the patient be so poor that he cannot afford even a slight loss of blood, as is frequently the case in long-drawn-out cutaneous burns, thin razor grafts or small deep grafts may be placed directly on the intact granulations with a reasonable assurance of "taking" (352, 305, 12, 191, 90, 199, 174), although, for reasons already given, the degree of contraction will be somewhat greater than if the granulations had been sliced.

The depth to which the granulations are to be excised will depend upon the type of graft to be employed. If the area is to be covered with a thin razor graft, the granulations are sliced superficially If a thick razor graft is to be used, they are shaved down to a firm yellow scar base, which, however, must not be deep enough to expose bone or tendon. In this connection Blair (25) says "Checked up observations show that the 'take' would average much nearer perfect on a scar base prepared by shaving off granulations than on the natural surface of granulations. The granulations are not scraped but sliced cleanly down to a firm yellowish scar base which is found below the depth of the velvet." If an avascular base persists in spite of deep removal, it may be better to risk putting the graft directly on this base rather than to expose bare bone or tendon by further dissection. In those rare instances in which a full thickness graft is to be placed on a granulating surface, it is essential that all scar tissue be excised. In such cases the cicatricial tissue is sliced off layer by layer, until a yielding, well vascularized base is exposed.

After the recipient area has been prepared and all bleeding controlled, the surface is covered with a pad wrung out of hot normal salt solution, and attention is directed to the donor region. Before removing the graft, the operating personnel effect a complete change of sterile raiment and are supplied with fresh sterile instruments to prevent the carrying of infection from the recipient to the donor area.

Removal of Graft. The graft may be cut from any healthy surface of the body, the source having little effect on its viability It is best taken, however, from regions where the skin is thin and soft and comparatively free from hair or glands and where the resulting scar will be inconspicuous, the most convenient sites thus being the inner side of the arm, the chest, the abdomen, and the anterior and outer surfaces of the upper part of the thigh. If the thigh is to serve as the donor area, the right limb is preferred, on the grounds that there is less likelihood of phlebitis.

Preparation of the donor area is begun on the eve of operation The part is shaved, scrubbed with green soap and water, rinsed with sterile water, washed with 70 per cent alcohol, and again rinsed with normal salt solution. As in the recipient area, no strong chemical should be applied, since it may interfere with the viability of the graft. Following the cleansing, the entire field is covered with a light aseptic dressing rendered adhesive with mastisol, this dressing is not disturbed until the time of operation. Immediately before surgery, the dressing is removed, and the donor area is again scrubbed with green soap and water, washed in sterile water, dried, and swabbed with alcohol followed by ether, after which the parts are draped and anesthetized.

When the upper anterior surface of the thigh is to serve as the donor area, anesthesia is best secured by blocking of the femoral nerve. Through an intradermal wheal (p 412) raised below Poupart's ligament at a distance of 1 to 1.5 cm. lateral to the femoral artery, a fine unmounted needle is inserted and gently pushed forward until it passes through the fascia lata. The correct position of the needle is determined by drawing it back and forth in various directions until a sharp pain in the

area supplied by the nerve is induced Without disturbance to the needle a #20 cc syringe containing a 2 per cent procain epinephrin solution is attached to it The piston is slowly withdrawn and, if blood appears in the cylinder, the needle is removed and reinserted in another direction Otherwise, 5 to 10 cc of the solution are slowly delivered into the tissues

If the upper lateral surface of the thigh is to be used, the lateral femoral cutaneous nerve is blocked The needle is inserted at a point about 2.5 cm below and medial to the anterior superior spine of the ilium and is made to pass in a downward and outward direction through the subcutaneous tissue and the superficial fascia, at which point 20 cc of a 0 5 per cent procain-epinephrin solution are injected

In all other areas a circular block is preferable (fig 197) The operative site is circumscribed by a series of intradermal wheals 5 to 10 cm. apart A long needle is then inserted into each of the wheals thus made and is carried down vertically to the subcutaneous tissues, a 0 5 per cent procain epinephrin solution being injected as the needle traverses the tissues Within 10 minutes of the injection, the entire operative area will have been isolated by a wall of anesthesia

The technic of cutting the transplant, its placement on the recipient site, and the care of the donor site vary with the type of graft and will be discussed in the sections dealing with special grafts Here it need only be said that there should be as little delay as possible in the transfer to the new bed If, for some reason, a short delay is unavoidable, the graft is either left on the donor site or is wrapped in gauze moistened with saline solution until ready for use For longer preservation it may be safely stored in a refrigerator for several hours

It is generally conceded that the more intimate the connection between the graft and its bed, the more likelihood there is of a successful "take" The best way to assure this relationship is to apply the graft as a single piece on a dry, even surface, and quilt it down to its bed by means of multiple mattress-sutures Any intervening media, such as blood-clots, serum, or air, interfere with approximation and lead to infection and sloughing Therefore, if there is any question as to the dryness of the bed, many stab holes are made over the surface of the graft with a sharp knife, so as to permit of the escape of secretions (346) In placing the graft, care should be taken to orient it in relation to the axis of its original blood supply, since there is some evidence to indicate that the re-establishment of the circulation is partly dependent upon the relation of the vessels of the graft to the surrounding structures Paterno (269) demonstrated that skin grafts cut and replaced in their original bed without change of orientation showed a 100 per cent survival, with re-establishment of the circulation in the graft as early as the second day, of grafts rotated 180 degrees from their original positions, 80 per cent survived completely and 20 per cent partially, the circulation not being re-established until the fourth day, and of those rotated 90 degrees, 66 per cent survived completely, 20 per cent partially, and 14 per cent failed to "take"

Dressing. *The dressing of the grafted area* is an essential element of the operation, and many and varied have been the types, both dry and moist, that have been recommended Irrespective of the variety, the dressing must be non-adherent, absorptive, protective, capable of exerting firm, even pressure, and of immobilizing the graft From within out, the dressing consists of the following layers (fig 61):

First Layer. That part of the dressing which is to lie immediately over the graft

should be non-adhering and sufficiently permeable to allow the escape of secretions. Many materials have been suggested, and all are probably equally effective, the choice being a matter of personal preference. Wide-meshed gauze impregnated with 3 to 5 per cent xeroform ointment serves the purpose well. Not more than two layers should be used, a greater number may seal the graft, and the resultant retention of secretions may lead to its maceration or elevation. Other materials recommended are "tulle gras," an open mesh net impregnated with vaselin containing 1 per cent Balsam of Peru, wide meshed paraffined gauze, and perforated cellophane or rubber tissue. Halsted (151) preferred silver foil. This makes a good dressing, provided the graft is successful, but should it fail, the silver may cause discoloration of the scar. Shifting of the graft during the application of the remainder of the dressing may be

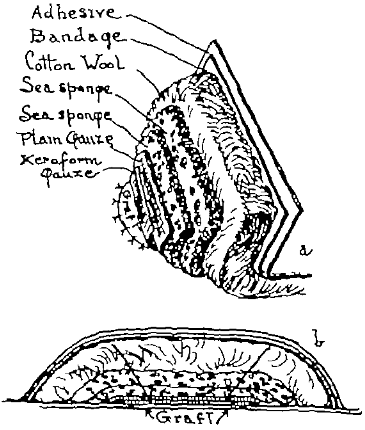

FIG. 61 Pressure dressing for skin grafts. a, layers of dressing. b, sectional view; arrows showing focus of pressure. For details, see text.

prevented by tacking the first layer to the surrounding skin with a few marginal sutures, or by cementing it down with mastisol.

Second Layer. The function of this layer is to absorb secretions and to protect the graft against trauma and external contamination. The xeroform gauze is overlaid smoothly with a pad of gauze wrung dry of normal salt solution and trimmed so that it will just cover the graft. In the application of this layer care should be taken to avoid the creation of wrinkles, as they have a tendency to injure the newly formed epithelium. Blair (25) has observed in grafts with improperly applied dressings patterns of damaged epithelium which seemed to correspond to the wrinkles in the dressing. A second dry pad, slightly larger than the first, is superimposed over the moist one, and the dressing is then built up, each successive layer being slightly larger

than the preceding one, until approximately 5 or 6 pads of dry gauze have been applied. The purpose of gradually increasing the size of the layers is to focus pressure on the graft Over the gauze is placed a thick layer of fluff gauze, which in turn is covered with a pad of cotton wool The whole is maintained in place with strips of flamed adhesive tape or by attaching the outer layer to the skin with mastisol

Third Layer. The purpose of this layer is to produce firm, even pressure, and this constitutes the most important part of the dressing (25) as the pressure brings the graft and its bed into intimate contact and thus eliminates dead spaces, controls oozing, limits lymphatic and venous stasis, and minimizes contraction While the importance of pressure is well established, considerable judgment must be exercised to secure the proper amount in each particular case If pressure is insufficient, secretions will collect beneath the graft and jeopardize its nutrition If, on the other hand, it is too

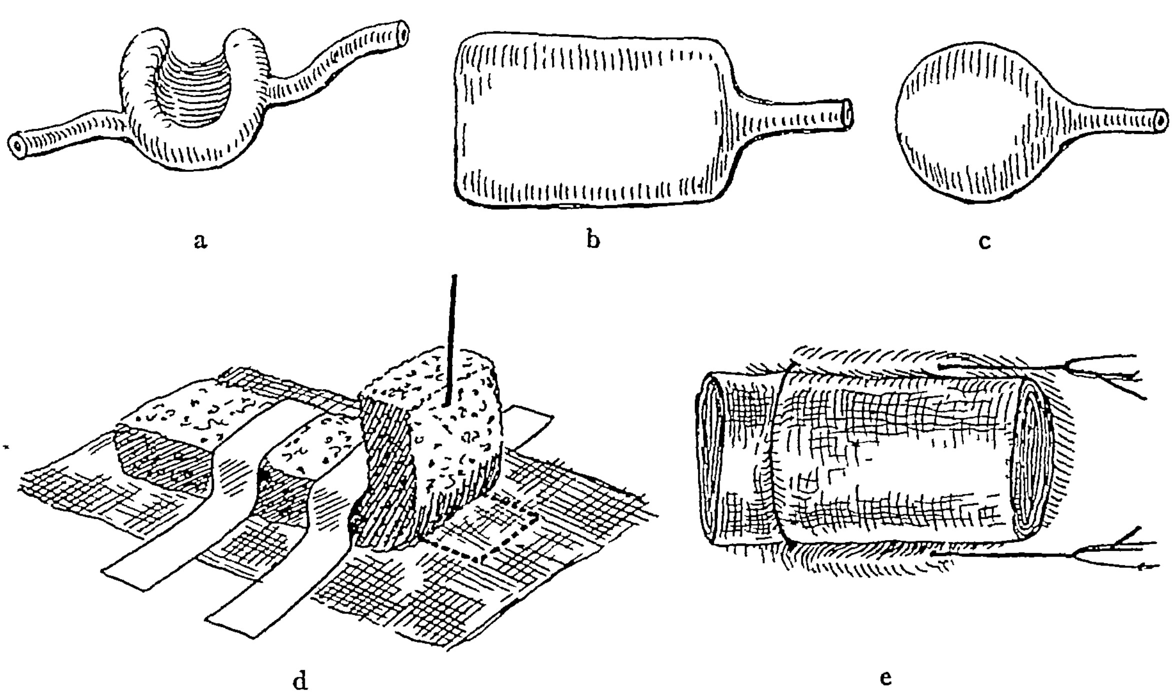

FIG 62 Other means of applying pressure *a–c*, inflatable rubber bags (Ferris Smith) *d*, rubber sponge, held in place by elastoplast (Kirschner) *e*, dressing held in place by two deeply buried sutures (Galtier) For details, see text

great, as is likely to happen over a bony prominence, it occludes the capillaries of the bed and leads to ischemia and death of the graft, and may even cause necrosis of the surrounding tissues In such cases the symptoms are remarkably few, and for this reason the part should be frequently inspected, at the first sign of undue pressure the dressing must be removed and the area treated, even at the expense of the graft. Generally speaking, the amount of pressure to be exerted will depend upon the type of graft and the character of its bed The thicker the graft, the greater the pressure required Locations which offer a firm, even surface, such as the forehead, require less pressure than those which are uneven or non-resistant, such as the cheek or the front of the neck Smith (313) has estimated the ideal pressure for full thickness grafts to be 30 mm of mercury to the square inch

The best means of assuring firm, even pressure, is by the use of some elastic material fixed over the previously applied layers A good quality sea sponge serves the purpose

well, as it not only exerts the necessary pressure on the graft, but also helps to immobilize it. A thin piece of this material, wrung out of normal salt solution and cut to fit the defect, is placed over the previously applied dressing Another layer of the same material, 3 to 4 cm. thick, is then superimposed, so that it extends 2 to 3 cm beyond the first. The whole is secured by a bandage, applied with even pressure, and tightened so as to remove one-third to one-half of the elastic spring of the sponge. Inflatable rubber balloons (313) (fig 62) and elastoplast bandages constitute other means for obtaining pressure. Kirschner (189) recommends a rubber sponge made sterile by being boiled in physiologic salt solution and squeezed dry It is held in place with elastoplast under slight tension (fig 62) Galtier (120) obtains pressure

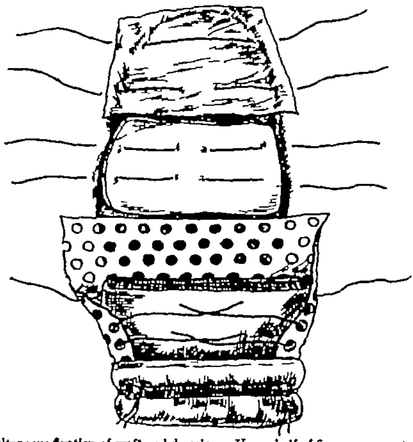

FIG 63 Simultaneous fixation of graft and dressing. Upper half of figure represents thin razor graft and fully dissected skin graft fixed to base by silk threads. Lower half represents dressing composed from within outward of layer of perforated protective, thick layer of sterile gauze, overall layer of gauze, whole held in place by previously passed silk sutures tied over rubber tubing (Samuel)

by holding the dressing in place with two deeply buried sutures (fig 62) With a Reverdin needle two sutures are passed subcutaneously along the two longest margins of the graft, at a distance of 1 cm. from the suture lines. The dressing is laid on the graft, and the two upper ends of the sutures are tied across it. Traction is now exerted on the other ends, and when the proper tension is obtained, these are tied in a similar manner across the lower end of the dressing, thus pulling it firmly and evenly against the graft. Galtier states that in this manner "the graft is compressed against the dressing, not the dressing against the graft."

The graft must be immobilized until its blood supply is established. This is especially important throughout the first few days, as during this period any shifting

of the graft will traumatize the delicate newly forming capillary loops, and the resultant collection of blood beneath the graft will cause its loss

In fixed parts of the body the pressure dressing, if properly applied, is all that is necessary to secure the proper immobilization; but over irregular areas and where the base lacks resistance, such as on the eyelids and neck, and in inaccessible areas, like the nose and mouth, this does not suffice, and other means must be employed In such cases the use of dental modeling compound, commonly referred to as stent, is invaluable, as it acts in the dual capacity of pressure dressing and splint. The compound, having been softened in hot water, is pressed into every crevice and irregularity of the area to be grafted When it becomes hard, it is removed, clothed with the graft, raw surface out, replaced, and held in position by means of interrupted silk sutures (fig. 75) The needle is first passed through one edge of the wound margin and made to pick up the corresponding edge of the graft It is carried across the mold to the opposite side, where it engages the graft and the corresponding wound margin in a similar manner The ends are then tied over the mold under tension sufficient to hold the graft snugly in its bed For skin grafting within the nose and mouth, the graft-covered mold is most conveniently held in place by the use of splints affixed to the teeth (fig 76) The details of grafting on a mold will be given later (p. 141) Coelst (55) uses a transparent celluloid frame in place of modeling compound, claiming that it permits inspection of the graft

In grafting operations about the cheeks, as an additional precaution against shifting of the graft, the jaws are immobilized by intermaxillary wiring of the teeth, the patient being fed through a Rehfuss tube In the vicinity of joints, especially in children where restraint is necessary, adequate immobilization can be secured only by the use of padded splints or plaster of Paris The latter material is the more satisfactory. The dressing and the surrounding area are first covered with stockinette This is overlaid smoothly with 2 to 4 layers of eider down, this, in turn, is covered with a layer of crêpe paper bandage, bony prominences are protected from pressure by felt paddings The plaster bandages are immersed in cold water and held there until the water stops bubbling, after which they are removed and the excess moisture is squeezed out with the hands The bandage is then unrolled and wrapped around the part in successive layers, each turn of the bandage being smoothed out with the hands. If certain areas need reinforcement, the bandage is doubled on itself over these parts While the plaster is drying, it should not be allowed to rest on a hard surface, as this may cause distortion of the cast and result in undue pressure on the underlying parts when it becomes hardened After the cast has been applied, the part should be watched for possible interference with the circulation, as evidenced by pallor or cyanosis The appearance of these symptoms obviously necessitates immediate splitting of the cast

If there is any question as to the aseptic condition of the grafted area, Carrel's irrigating tubes are incorporated in the second layer of the dressing and the part kept moist by the introduction of normal salt solution in the manner described on page 276 Blair (26) states· "We have concluded that the use of the continual wet dressing gives a better chance to 'take' than a dry or greasy dressing This conclusion has been arrived at in spite of the apparent messiness and objectionable odor accompanying the procedure "

The *dressing of the donor area* does not differ from that of any surgical wound The part is covered with some non-adhering material, such as xeroform gauze or silver-

foil. Over this several layers of gauze are superimposed, covering a wide margin of skin around the wound. Whether to employ the gauze moist or dry is a matter of personal preference. Moist gauze is softer and more adhesive, but dry gauze absorbs secretions more readily and has less tendency to encourage bacterial growth. On top of the gauze is placed a thick layer of absorbent cotton. The entire dressing is held in place by a roller bandage only enough pressure being exerted to limit oozing and to obliterate dead spaces. Finally the bandage is supported by adhesive strips placed in a circular fashion so that the ends overlap, and these are reinforced with strips placed longitudinally Recently, the use of tannic acid has been adopted in dressing the donor area. It is applied in the same manner as for a burn For details of the technic the reader is referred to Chapter IV If the donor area is skin-grafted, the customary pressure dressing for a skin graft is applied.

Postoperative Management. The success or failure of skin-grafting is influenced to a great extent by the character of the postoperative management. Following the application of the dressing, the part is placed at rest, since any movement predisposes to shifting of the graft and hemorrhage. The position in which the part is to be placed will depend upon its blood supply Where the circulation is strong and the location permits it is elevated, and, conversely, where it is sluggish, it is made to assume a dependent position. If the nutrition of the base is questionable the circulation may be enhanced by placing the grafted area for several hours a day in a cradle maintained at a temperature of 80°F

The time of the first *postoperative dressing* and the frequency of subsequent dressings cannot be arbitrarily stated, in view of the different types of grafts and of the varying character of the bases upon which they are placed. Generally speaking, in the absence of complications such as infection, hemorrhage, and odor of sloughing, the dressing should not be disturbed until the graft has become vascularized A premature change inflicts more or less trauma, disturbs the newly forming capillary loops, and may cause the graft to melt away Theoretically, the dressing of a graft which has been placed on an aseptic surface, should not be interfered with for 2 or 3 weeks, as this length of time is required for the graft to become firmly attached. Nevertheless, it is practical to inspect the part on the eighth to the tenth postoperative day If the graft has "taken,"—in which case it will have assumed a pink appearance—a second pressure dressing similar to the first is applied for another week or two, and little damage will have been inflicted by the interference. But if some minor fault is discovered, prompt attention may save the life of the transplant. If secretions have formed beneath the graft, they are evacuated through a small opening Should blisters be found on the surface, they are opened, as they have a tendency to become infected and may ulcerate through the entire thickness of the graft. If the outer layer of epidermis has been cast off but a thin pellicle of basal cells, active and still attached to the granulations in the form of small islands, remains, a good part of the graft may be saved by a gentle cleansing of the part with normal salt solution and its exposal to warm air in a heated cradle. In time the entire surface will be covered over with epithelium which has proliferated from the islands of viable cells If the graft is loose and presents a dead white appearance, it should be removed and the area treated until a more nutritive base can be secured, before a second grafting operation is attempted. If the graft has been cast off and there is a gross amount of pus present, the dead tissue is excised and all sloughs and granulations are carefully trimmed away

The area is then cleansed and treated with warm moist pressure dressings or by continuous irrigation with Dakin's solution, until it is in the proper condition for another attempt at grafting While early sepsis invariably causes a total loss of the graft, when it sets in late, there is a possibility that a part of the transplant may be saved

When the graft has been applied to an aseptic granulating surface, the dressing is left undisturbed for 8 to 10 days When placed on an infected surface, however, where a certain amount of exudation is present, it is changed within the first 24 to 48 hours and thereafter as often as is necessary to keep the parts from becoming macerated At each dressing all the layers down to the protective are removed, the secretions are gently wiped away, and a fresh outer dressing applied

In redressing the grafted area the same aseptic precautions should be taken as in the application of the graft After the outer dressings have been removed, sterile gloves are donned, the field is draped with sterile towels, and the layers lying immediately over the graft are carefully peeled off with sterile forceps As a rule, they come off easily, but, if adherent, they may be gently soaked loose with normal salt solution or sterile oil Secretions, if present, are removed with a sponge held in a forceps, and redundant edges are trimmed away If sutures have been introduced, they are taken out Finally, another pressure dressing similar to the original one is applied.

After discontinuance of the dressings, the grafted area is exposed to the air and protected for another month or two against possible mechanical or thermal injury. At the end of this period gentle massage with a bland ointment, such as cocoa butter, cold cream, or lanolin, is instituted several times daily and continued until the graft slides easily over the underlying tissues This will improve the circulation, soften the graft and the marginal scars, prevent scaling, and provide a more stable surface If the graft has been applied in the vicinity of a joint, active and passive motion are begun as soon as healing is complete. Exposure of the part to ultraviolet light may also be of advantage

Special Skin Grafts

Small Thin Razor Grafts

The resurfacing of denuded areas by the use of small thin razor grafts is the oldest and simplest method of skin transplantation. It entails no involved preparation, is easy of execution, causes but little pain, can be done under local anesthesia, and is but slightly suggestive of a "dreaded" operation. The dressings and instruments are not elaborate, and the after-care is not irksome These minute transplants will "take" on any raw surface and under conditions contraindicating the use of other more complicated methods, indeed, they will often remain viable even in the presence of considerable suppuration Furthermore, should a greater or a lesser portion of the grafts fail, it is no great calamity, since the loss can easily be remedied by a repetition of the process The simple after-treatment permits of the use of these transplants in the case of ambulatory patients, and the minor character of the operation renders them especially applicable in the old and the debilitated, whose condition does not warrant the more elaborate technic required in the application of other grafts

Unfortunately, however, the extent of their usefulness is limited Because of their small size and thinness the new covering which they provide has a marked tendency to

contract and break down under comparatively slight provocation, and is often but little better than ordinary scar tissue. The mosaic appearance resulting from the mingling of the darker grafts with the lighter intervening cicatricial tissue is objectionable, and, due to scar tissue adherence, movability over the underlying tissue is seldom obtained. In view of these undesirable features, this graft has been largely replaced by other more satisfactory ones, and its use is limited chiefly to the treatment of patients in

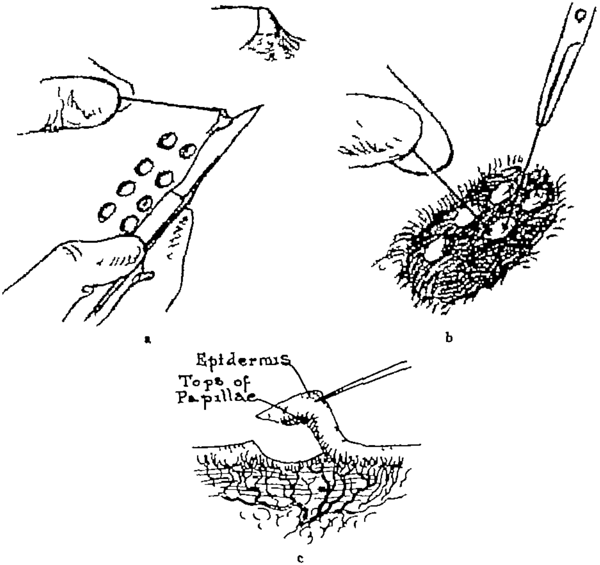

FIG. 64. Small thin razor grafts. *a* small island of epidermis raised on point of cambric needle, and morsel of tissue comprising epidermis and superficial layer of dermis cut with sharp knife. *b* grafts on point of needle transferred to recipient area, raw surface down. *c* sectional view showing depth at which graft is cut (Davis)

whom the degree of infection is too pronounced to warrant the success of any other graft, and where rapid resurfacing is desired without much reference to anything else

Technic. Prior to the placing of small thin razor grafts, the granulations on the recipient area require little preparation Indeed, this constitutes their main advantage. They may be implanted as soon as signs of acute inflammation have subsided

The graft is obtained in the following manner A small island of epidermis is raised on the point of a cambric needle, and with a sharp knife a morsel of tissue 4 to 5 mm in diameter, consisting of epidermis and the most superficial layer of the dermis, is

removed If the graft has been properly cut, there occurs at the base of the tiny crater formed by the section a slight oozing of blood, representing the point at which the apex of the papilla was severed (fig 64). Care must be taken to avoid cutting these grafts at a deeper level, otherwise, permanent scars will be left on the donor area, and the thick layer of connective tissue on the base of the graft will interfere with its viability, especially if the recipient area is infected As each graft is excised, the assistant picks up the needle with the impaled graft, and presses it, raw surface down, on the denuded area, to which it readily adheres The grafts are placed in rows, at a distance from one another and from the edge of the ulcer not exceeding 1 5 cm The more closely they are placed, the better, since the proliferation from their edges is limited, and the more numerous the grafts, the more rapid the healing If the operation is performed in stages, the grafts are placed around the border of the wound at the first sitting, and at a later date the balance of the wound is covered

When all the grafts have been placed, a layer of perforated cellophane, of xeroform gauze, or of some other non-adherent material is laid over the area Above this are placed a few layers of gauze wrung out of saline solution, and these in turn are covered with 2 or 3 layers of dry gauze, the whole being held in place by a roller bandage While in this type of graft the dressing is not an essential feature, nevertheless it is well to provide some sort of protection

The time when the dressing is to be changed will depend upon the nature of the area upon which the graft was placed If the base was aseptic, the dressing is left undisturbed until the part is completely epithelized, but if septic, as is usually the case when these grafts are used, a change of dressing is required every 24 to 48 hours, depending upon the amount of discharge

The condition of the grafted area at the first postoperative dressing is usually discouraging, and often the operation will seem to have failed because the outer layer of epithelium degenerates and is cast off Careful observation, however, will reveal a pale bluish line around the islands of epithelium, and the proliferating base of the graft will be found to have taken root In a week these islands will have proliferated in all directions and will eventually coalesce to cover the denuded area Freeman (117) describes the changes that take place as follows After the grafts have been applied, they adhere to the surface, and in 24 hours they appear whiter, thicker, and softer In another 24 to 72 hours those which have "taken" show a pink color surrounded by a reddish zone Then a thin, grayish pellicle begins to grow out of their margins and from adjacent margins of the wound, like ice from the shores of a pond Some of the grafts will turn brown and die. Others will remain white and lose the superficial areas of epidermis The new epithelial film in time sends filaments horizontally from the margins to cover the surface, and vertically to penetrate the base and anchor the graft. In time the grafts coalesce with one another and with the borders of the wound

Large Thin Razor Grafts

Until the introduction of the thick razor graft by Blair (26) in 1928, the large thin razor graft was the most widely used type of transplant Its application is simple, easy, and rapid, the grafts may be obtained in any size, limited only by the available donor surface and by the dexterity of the operator Owing to their thinness and comparative avascularity, they are capable of receiving nutrition through direct

osmosis from the surrounding lymph spaces, hence they have a reasonable assurance of remaining viable even when placed on intact granulations or on a moderately contaminated surface. The donor area heals spontaneously and in a short time, without appreciable scarring Nevertheless, they have definite disadvantages which limit their field of applicability Inasmuch as they contain a very small portion of the corium, they afford inadequate protection to areas subject to pressure or friction, and under slight trauma they are prone to break down, leaving slow healing ulcers. Also because of their thinness they will not correct inequalities of the underlying surface, and are inapplicable around joints, as they do not prevent contraction of the raw surface beneath Finally, they are subject to discoloration which renders their use objectionable on exposed parts, such as the face.

The large thin razor graft is invaluable in resurfacing sizable skin defects on unexposed areas in which the bacterial state of the bed is questionable, or where the poor general condition of the patient prohibits the more elaborate operative procedure necessitated by thicker grafts, for example, for the resurfacing of large denuded areas following burns It finds its greatest application in the replacement of extensive

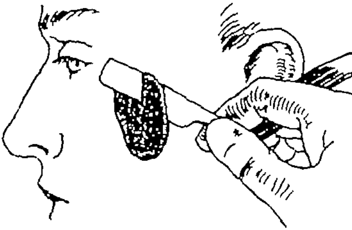

Fig 65 Slicing of granulating area. Area circumscribed by incision outside scarred margin and sliced with razor down to firm, yellow well-vascularized substratum.

losses of mucous membrane, such as that of the nose, mouth (337), larynx (104, 247), middle ear (283), parotid duct (276), esophagus, bladder, urethra, and vagina. Like the small thin razor graft and the small deep graft, the large thin razor graft is frequently employed as a temporary covering for large granulating surfaces, to be supplanted later by a more pliable and more durable transplant.

Technic. The recipient area is aseptically prepared in the manner already described, and the granulations are sliced off (fig 65) or, if necessary, left intact. The part is covered with a compress of hot normal salt solution, and the graft is cut. The donor area, preferably some hairless part of the body, such as the upper arm or thigh, is prepared, draped, and anesthetized in the usual manner The cutting of the graft requires no great skill, provided the skin is immobilized under the proper degree of tension, and the knife is sharp

Stretching of Skin In the removal of small grafts from the thigh support is obtained from below by placing a sand bag beneath the limb, and while the assistant presses the inner edge of his hand into the skin across the upper limit of the donor site and pulls upward, the surgeon standing with his back towards the patient's

feet, digs his left hand into the lower limit in a similar manner and draws the skin downward Another convenient method for stretching the skin prior to the removal of small grafts is to insert subcutaneously across the upper and lower extremities of the proposed graft two long pins which, when pulled in opposite directions, will leave a flat surface (fig 69)

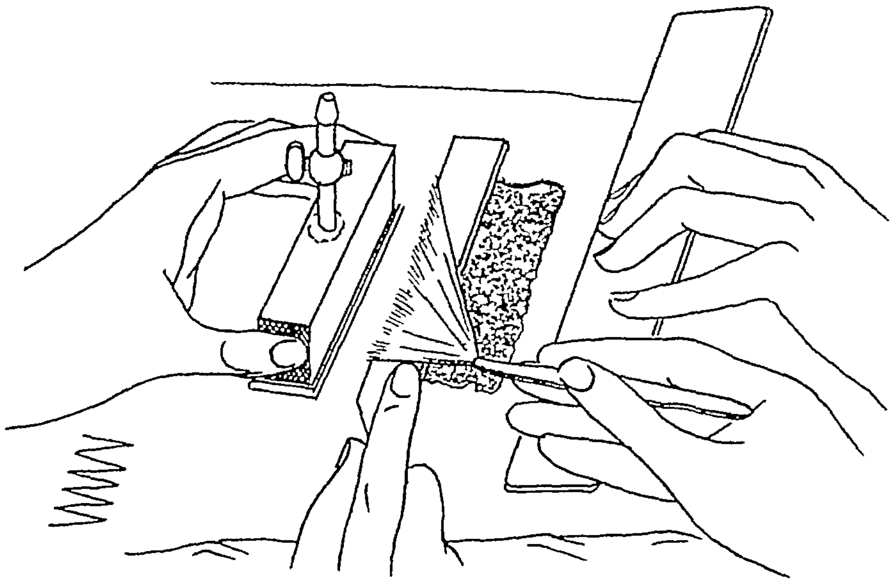

FIG 66 Stretching skin prior to cutting large razor grafts By use of suction retractor (Blair)

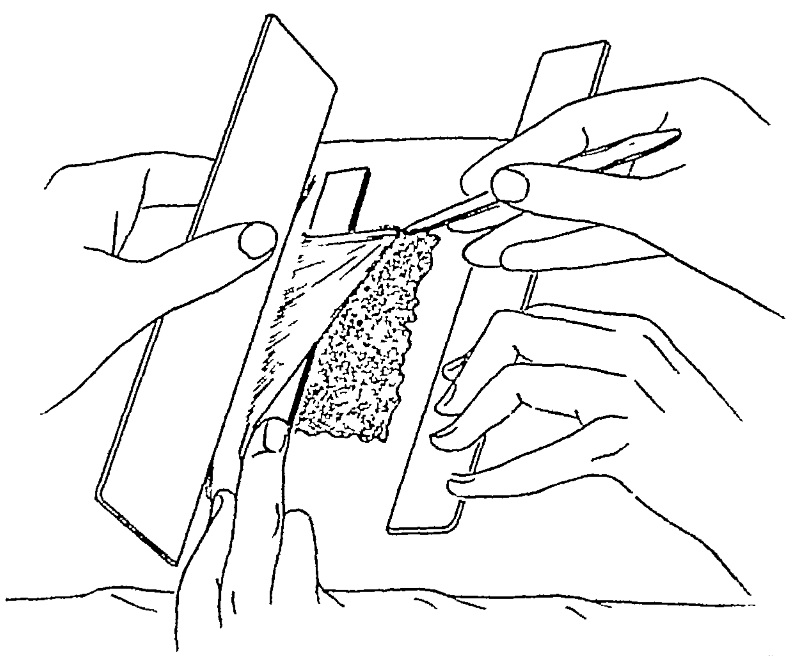

FIG 67. Stretching skin prior to cutting large razor grafts By use of two basswood boards (Davis)

To cut large grafts, especially in patients with little subcutaneous fat, in children, or on the abdomen, the above methods of securing tension are inadequate Here the use of Blair's suction box, already described, greatly facilitates the procedure (fig 66) In the absence of this instrument the skin may be stretched between two basswood boards pulled in opposite directions The greased edge of one board, held by the assistant, is applied transversely across the upper limit of the donor area, and its position is adjusted until a flat surface, sufficiently broad for the required

graft, is produced. The other board, held in the left hand of the surgeon, exerts countertraction and is moved downward as the knife advances in front of it (fig 67)

To facilitate the cutting of large thin razor grafts Daggett and Bateman (67) suggest painting the skin of the donor area with 1 per cent methylene blue, covering it with a thin film of flexible collodion, and allowing it to dry The collodion, by stiffening the skin, makes cutting easier and prevents the edges of the graft from curling while the methylene blue offers a contrast between the epithelial and the raw surface.

Cutting of Graft With the donor skin held under proper tension by any one of the above methods, the graft is cut. It should be of uniform thickness throughout, and preferably in a single sheet large enough to overlap the wound edges, the use of a number of smaller grafts is objectionable as they cause the surface to stand out in ridges where the separate pieces overlap Any excess graft may be stored in sterile

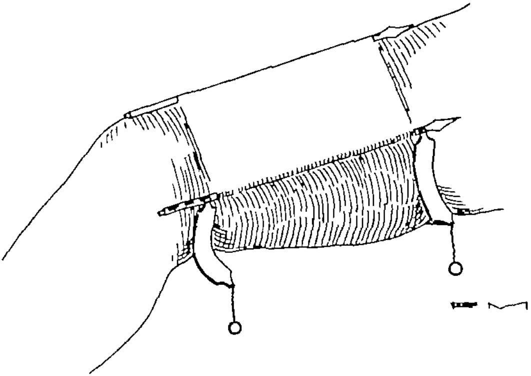

FIG 68. *Stretching skin prior to cutting large razor grafts* By use of skin elevator (Kirschner)

vaselin in a refrigerator and used subsequently, either on the same or on another patient.

If the graft is to be cut with the aid of a suction retractor, "a very thin film of vaseline is applied to the donor area and gently wiped off with a gauze sponge. Too much vaseline allows the box to slip too easily with too little it will drag and cause ecchymosis" (26) A Blair knife is stropped and covered with a film of oil, not too thick, however as it may seep under the graft and interfere with its adhesion. The upper end of the field is fixed with the edge of a board in the hands of an assistant. The suction retractor, held in the left hand of the surgeon, is placed on the skin below the board, and the suction is turned on The knife, held loosely in a violin bow position in the surgeon's right hand, is applied to the skin flatwise at the upper limit of the proposed graft in back of the suction box and is worked rapidly back and forth until it engages the epithelial layer Then, with a gentle rapid sawing motion, it is drawn

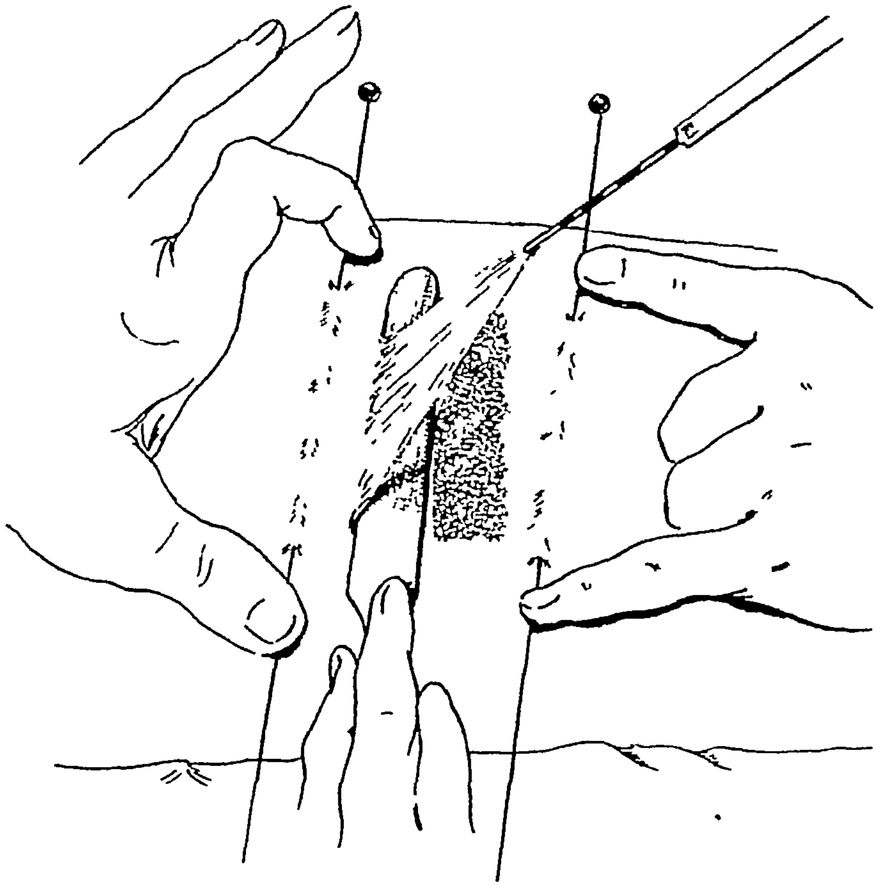

FIG 69 Stretching skin prior to cutting large razor grafts By use of two pins inserted subcutaneously at upper and lower levels of proposed graft

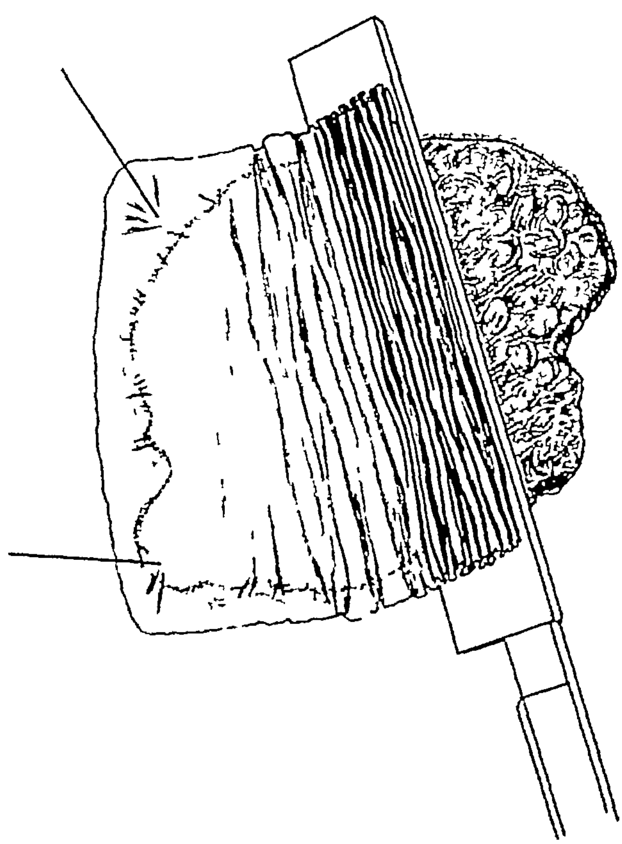

FIG 70 Transfer of thin razor graft to recipient area on blade of knife

downward as the suction retractor recedes before it (fig 66) If the graft is cut at the proper level, it will run over the back of the knife like a piece of crêpe tissue paper, and the surface beneath will be studded with minute, punctiform, slow-appearing *hemorrhages exuding from the tops of the cut papillae.*

Transfer of Graft to Recipient Area When the graft has been cut, it is transferred while still on the back of the knife to the recipient area. The graft laden blade is approximated to the distal border of the bed about to receive it, and, while the as-

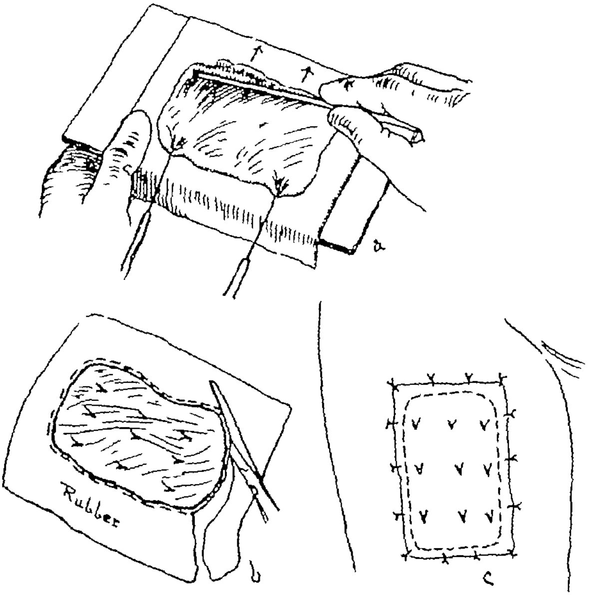

FIG 71 Transfer of graft to recipient area *a*, graft spread on rubber tissue which will serve as first layer of dressing *b* *graft and rubber tissue covering perforated for drainage and trimmed to fit defect.* *c* rubber tissue tacked to surrounding skin to prevent shifting of graft (Davis)

sistant fixes the upper edge of the transplant *with a probe the knife is slowly drawn* across the wound the thin sheet spreading out behind it (fig 70) Another con venient method consists of spreading the graft back *on its bed before the cutting* of the distal margin and covering it with a piece of cellophane or rubber tissue, which, if desired, may later serve as the first layer of the dressing The graft is then freed from its remaining attachment transferred to a board, and perforated in many places with

the point of a sharp knife (fig 71) If the perforations are made while the graft is still on the donor area, they may penetrate more deeply than is intended and cause unnecessary damage to the bed The perforated graft is laid on the recipient surface, raw side down, so as to slightly overlap the wound edges, to prevent shifting, it is tacked to the surrounding skin by interrupted stitches of horsehair, or #0000 plain silk on an eyeless needle. *When several grafts are used, the strips are gently arranged* with probes, so that they not only cover the margins of the wound but overlap each other shingle-fashion, otherwise, since the margins are necessarily made up of the horny layer only, without the proliferative basal layer, cicatricial tissue may form between the grafts To prevent displacement, they are tacked down to the base by means of mattress-sutures passed through their overlapping margins Just before the dressing is applied, air bubbles and secretions which may have accumulated beneath the graft are gently pressed out by means of a cylinder of gauze rolled over the area

Dressing and After-Care The dressing and after-care of the recipient area have already been discussed Samuel (302) fixes the graft and the dressing simultaneously (fig 63): A silk suture is passed through the skin adjacent to the wound margin, from here it is made to enter the graft, taking a bite of the underlying tissue, then through the skin adjacent to the opposite wound margin, the threads being left long After the dressing has been applied, the ends of the suture material are threaded through rubber tubing and tied over the dressing

The donor area is either covered with an ordinary surgical dressing (p 86) or treated with tannic acid, in the same manner as a burn The coagulum that forms will separate spontaneously in two weeks, leaving an epithelized surface

Other Methods of Applying Thin Razor Grafts

(1) **Implantation Grafts.** This method, originally described by Pollock (283) in 1870 and revived by Braun (32) in 1920, consists in the implantation of small thin razor grafts, 2 to 4 mm square, directly into the granulations, in much the same way one would plant seeds in the ground These grafts provide a simple and effective means of covering denuded surfaces The only condition necessary for their success is the presence of granulations, even though they be unhealthy The percentage of "takes" is high, because perfect and constant approximation of the graft to its bed is assured Also, the period of healing is considerably shortened, as the islands of skin that arise coalesce far earlier than in surface transplants Complex dressings and provision for immobilization are unnecessary, therefore, these grafts find special application in the case of ambulatory patients Their advantages, however, are outweighed by the fact that the epithelial cover is little better than a scar, breaks down under slight trauma, and is prone to undergo keloidal degeneration. Thus the use of this type of graft is limited to the resurfacing of defects on which other grafts would obviously fail, as, for instance, infected granulations following burns, osteomyelitic cavities, and decubitus ulcers

Technic After aseptic preparation of the recipient area the donor site is cleansed and anesthetized A strip of thin razor graft is obtained in the usual way and cut into sections 2 to 3 mm square Or, the sections may be removed individually in a manner similar to that of procuring small thin razor grafts (fig 72). The segments are picked up individually on the blunt end of a straight needle held in a hemostat and

introduced obliquely into the granulations for a distance of 3 to 4 mm , or until the grafts just barely disappear from sight. If the graft tends to be drawn out on removal of the needle slight pressure by forceps will serve to retain it. The grafts are thus implanted at distances of 0.5 to 1 cm. from one another, until the entire granulating area is covered. Apparently they grow equally well, whether the skin side of the graft is directed up or down. The grafted area is covered with xeroform gauze and overlaid by a sterile dressing held in place with a bandage. Two or 3 days later the dressing is removed the grafted area inspected, and a fresh wet dressing applied Within 5 to 10 days after grafting a slight hollow appears at the site of every minute graft, in the center of each depression is a bluish-gray island of new epithelium, giving the grafted surface a mottled aspect. These islands rapidly increase in size, change

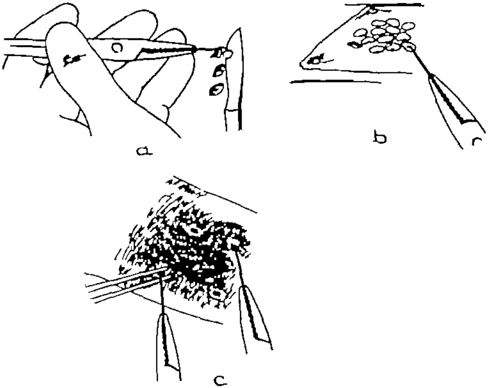

FIG. 72. Implantation grafts. *a* thin razor graft 2 mm. in diameter cut from donor site. *b* implants placed on rubber sheet. *c* grafts impaled on blunt end of needle introduced obliquely into granulations at distances of 0.5 to 1 cm. from one another until entire granulating area is covered Grafts retained with forceps as needle is withdrawn (Wangensteen)

to a lighter color, and soon a thin blue border of epithelium appears. In 6 to 18 days the whole granular surface is epithelized. The ultimate appearance is not unlike that following the healing of small thin razor grafts. The donor area is dressed in the same manner as that following the removal of the latter

(2) **Combined Surface and Buried Thin Razor Grafts.** Westhues (359) describes a method by which razor grafts are woven into the granulations. A strip of thin razor graft, cut in the usual manner is threaded through the eye of a large needle and woven in and out of the granulations, part of the graft remaining above and part below the surface. While such a graft combines the advantages of both surface and buried transplants, the method seems unnecessarily complicated.

(3) **Other Methods** Many other methods of employing epithelium for grafting

skin adjacent to the wound. It is then sutured to the surrounding skin by a continuous basting or whipping stitch with horsehair or #0000 silkworm-gut on an atraumatic needle In locations where an inconspicuous marginal scar is especially desirable, it is advisable to fit the graft accurately into the defect and to suture it to the wound margins as one would a full thickness graft. To ensure contact of the graft with the underlying raw area, it is tacked down by several mattress-sutures. Drainage is assured through multiple stab holes pricked into the graft with the point of a sharp knife

After blood-clots and serum have been expressed from beneath the graft, a light pressure bandage is applied and the part immobilized. On the eighth to the tenth

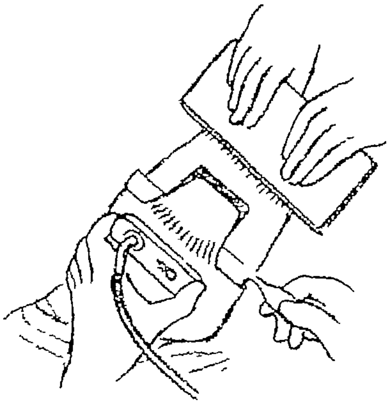

FIG 73 Removal of thick razor graft. Assistant presses edge of board at one end of field. Surgeon draws suction retractor ahead of advancing knife. (Blair)

postoperative day the dressing is taken down the sutures are removed, and another pressure dressing is applied. Subsequent dressings are changed at 2 or 3-day intervals for another 10 days or 2 weeks, after which the area is exposed to the air and treated in the manner already described The donor area is dressed like any surgical wound, and, if the graft was cut at the proper level, healing will be complete at the end of 2 weeks.

Grafting on a Mold

The application of a thin or a thick razor graft on a mold of dental compound (stent) is an invaluable procedure in the resurfacing of areas such as the eyelids, where it is impossible to obtain pressure by the use of an ordinary pressure dressing, or in areas difficult of access, such as the inside of the nose or mouth, and when it becomes neces-

have been suggested, but on the whole the results of these procedures have not been found sufficiently satisfactory to warrant their use

The application of *pulpified epidermis* was revived by von Mangoldt (230) (1895) The grafting material is procured as follows The skin of the donor area is prepared in the customary manner, moistened with salt solution, and scraped The first scrapings are discarded The second scrapings, composed of epithelium, serum, and blood, are applied to the denuded surface This material has been used for various purposes Von Hacker (145) used it to line a nasolacrimal duct, introducing it on a silk thread In Pels-Leusden's clinic in Greifswald, the material was forced into granulation tissue through a small syringe to hasten healing Reschke (289) injected it beneath a rodent ulcer

Lusk (217) employed the *skin of blisters* as grafting material A vesicle was raised by the use of a vesicating agent and the cuticle was removed, dried, and sterilized between glass plates, after which it was applied to the denuded area MacLeod (222) (1871) applied blister fluid to the raw area Scrapings of surface epithelium (309) and shavings of warts, corns, and calluses have also been used (200, 165) Dieffenbach (82), early in the nineteenth century, reported the successful implantation of *hair follicles* The procedure was later attempted by Wentscher (357) (1898), but without success

Alloplastic materials of all kinds have been employed, but their merits are few Hamilton (153) (1881) used thin layers of sterilized animal sponge with the hope of furnishing a scaffold for the granulations Berthold and Haug (20) (1889) used egg membrane

Thick Razor Grafts

In recent years, the thick razor graft (split-skin graft), incorporating $\frac{1}{3}$ to $\frac{3}{4}$ the full thickness of the skin, has largely replaced the thin razor graft and has infringed considerably on the domain of the full thickness graft They are superior to thin razor grafts because of their greater thickness, they are more likely to retain their natural color, show less contraction, afford better protection, are less easily traumatized and less prone to ulceration Moreover, their likelihood of "taking" is practically as certain as that of thin razor grafts As compared with the full thickness graft, they can be obtained more easily and in larger size, the donor area offers no problem, inasmuch as sufficient dermal structures are left to permit of spontaneous regeneration, they are more certain to "take" and may be transplanted even in a contaminated field, with reasonable assurance of success, less pressure is required in the dressing of the graft, and postoperative care is less exacting (59) These grafts are especially indicated to cover granulating surfaces in areas where the surrounding tissues are sufficiently tense to resist contraction, and are preferable to full thickness grafts in parts of the body where lack of thickness is a desirable quality, as within the antrum, on the eyelids, or on the lips

Technic. The recipient area is aseptically prepared, draped, and anesthetized If it is covered by granulations, they are sliced down to a firm, yellow, well-vascularized substratum The technic of procuring the graft is the same as that employed for the thin razor graft, except that the knife engages the skin at a deeper level (fig 73) When the graft has been cut, it is laid smoothly over the defect so that its edges overlap the

skin adjacent to the wound. It is then sutured to the surrounding skin by a continuous basting or whipping stitch with horsehair or #0000 silkworm gut on an atraumatic needle. In locations where an inconspicuous marginal scar is especially desirable, it is advisable to fit the graft accurately into the defect and to suture it to the wound margins as one would a full thickness graft. To ensure contact of the graft with the underlying raw area, it is tacked down by several mattress-sutures. Drainage is assured through multiple stab holes pricked into the graft with the point of a sharp knife.

After blood-clots and serum have been expressed from beneath the graft, a light pressure bandage is applied and the part immobilized. On the eighth to the tenth

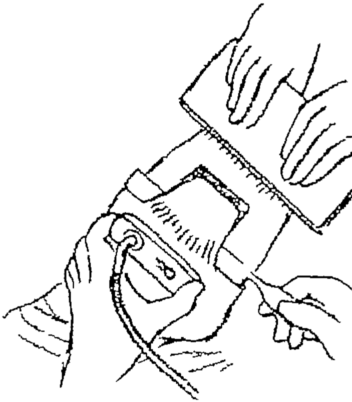

FIG 73 Removal of thick razor graft. Assistant presses edge of board at one end of field. Surgeon draws suction retractor ahead of advancing knife. (Blair)

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Grafting on a Mold

The application of a thin or a thick razor graft on a mold of dental compound (stent) is an invaluable procedure in the resurfacing of areas such as the eyelids, where it is impossible to obtain pressure by the use of an ordinary pressure dressing, or in areas difficult of access such as the inside of the nose or mouth, and when it becomes neces-

sary to construct a subcutaneous skin-lined cavity. The method was devised by Esser (104) in 1917 for the relief of a cicatricial obliteration of the labiogingival sulcus to render possible the fitting of an artificial denture Into a pocket created through an incision below the mandible he introduced a skin-graft-covered mold and closed the wound, thus completely burying the graft in the subcutaneous tissue After ten days, when the graft had become vascularized in its new location, the mold was removed through an incision in the mouth, a skin-lined cavity being left to replace the destroyed buccal sulcus (fig 74) This Esser called "epithelial inlay grafting" Since its original application, the method has been modified by a process termed "epithelial outlay grafting," wherein the graft-covered mold is applied directly to the surface to be grafted (350)

Technic In the *inlay method*, an incision is made over the site of the proposed graft and deepened to form a cavity Cicatricial tissue, if present, is removed throughout its entire extent The walls are trimmed to present an even surface so as to ensure contact between all parts of the graft and its bed To compensate for contraction, the cavity should be made somewhat larger than that ultimately required, and should

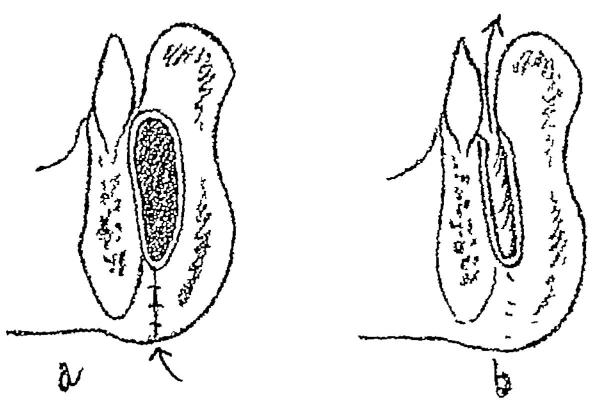


FIG 74 Grafting on mold Esser's original epithelial inlay for reconstruction of gingivolabial sulcus following cicatricial obliteration *a*, graft-covered mold introduced into prepared bed through incision below mandible *b*, after vascularization, mold removed through intra-oral incision, leaving epithelized cavity communicating with mouth

be so shaped as to permit of the easy introduction and removal of the mold As soon as hemostasis is secured and the part freed of accumulated blood, a piece of stent, softened in a hot water bath, is pressed into the cavity and allowed to harden The setting process can be hastened by allowing cold water to drip over the area When the hardening process is complete, the mold is removed, and will be found to bear the impression of every nook and crevice of the area to be grafted It is scratched with a knife at cardinal points so as to facilitate its orientation when reintroduced The mold should be of such a size that the edges of the wound can be approximated over it, although it is of no essential disadvantage if the suture line gapes a little

A razor graft of even thickness and preferably in one piece is then obtained in the usual manner The graft should be of such a size as to cover the entire mold If too small, raw areas will remain ungrafted to undergo ulceration and cicatrization, if too large, epithelial débris will accumulate which may interfere with the "take" The graft is stretched smoothly and evenly, raw surface out, over the mold, and the edges are united under slight tension by means of fine catgut sutures The graft-covered mold is then inserted into the cavity in such a manner that the graft margins

will lie beneath the surface wound. A hot compress is held over the surface for a minute or two to facilitate the adaptation of the mold to its bed, and after that the skin incision is closed with fine silk and a pressure bandage applied.

In the *outlay method*, the manner of preparing the base, of obtaining the impression of the area to be grafted, and of clothing the mold with the graft are the same as in the inlay method, but the means employed to secure immobilization are somewhat different. To fix the graft-covered mold on an exposed surface, sutures are employed. The needle is passed through one edge of the wound margin and the corresponding edge of the graft, it is then carried across the mold and made to pick up the graft and the opposite wound margin in a similar manner. Several such sutures are passed and the ends are tied over the mold under sufficient tension to hold the graft snugly in its

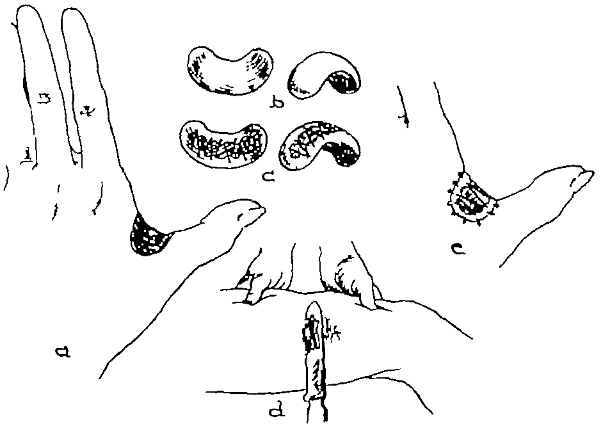


Fig 75 Grafting on mold by epithelial outlay used in areas where pressure is difficult to obtain by ordinary dressing *a*, area to be grafted *b* stent mold of area *c*, mold covered with graft. *d* graft removed. *e*, graft-covered mold sutured in place. (Pierce)

bed (fig. 75) To secure immobilization in areas difficult of access, such as the nasal and buccal cavities, the stent, clothed with the graft, is introduced on a tray and affixed to metal-capped splints on the teeth by means of an upright (fig 76)

After-Treatment. At the end of 10 days, the original suture line is incised, the margins of the wound are carefully retracted and the mold is lifted out, leaving an epithelized cavity underneath If the mold tends to drag on the graft, its removal may be facilitated by allowing a little albolene to penetrate the intervening space All redundant edges are trimmed and epithelial débris mopped out. To prevent subsequent contraction of the newly epithelized cavity, it is kept distended by a mold of gutta percha similar to the stent mold for a month or two, or for a longer period, being removed daily for cleansing purposes.

The special uses of this method of grafting—for example, to enlarge the conjunctival sac, to reconstruct the ear, to correct defects of the hard and soft palates, and to line skin flaps—will be described in the appropriate sections

Full Thickness Skin Grafts

Full thickness skin grafts comprise the several layers of the skin but not the subcutaneous fat Inasmuch as all the cutaneous histologic structures are retained, the grafted surface is soft, elastic, freely movable on the underlying structures, durable, and resistant to pressure, physiologically, the processes of desquamation, regeneration, and secretion are practically normal (33, 34) Unfortunately, this graft has many disadvantages Its field of application is limited to the covering of aseptic surfaces—

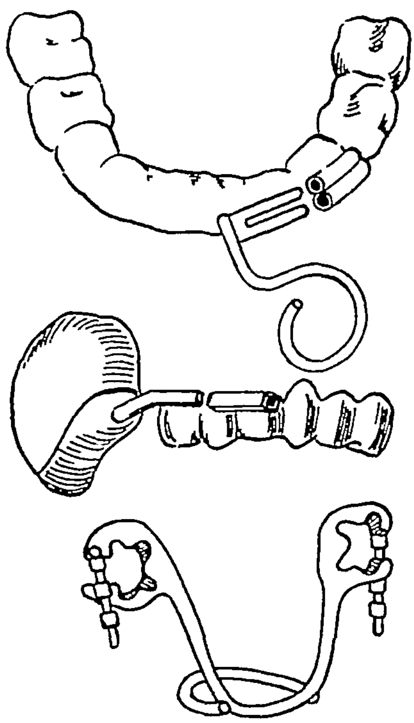


Fig 76 Intra-oral splints equipped with trays to hold modeling compound Used to immobilize skin grafts within buccal cavity (Kazanjian)

for example, a clean operative wound It is not likely to "take" on a granulating base since sterility of granulation tissue is seldom obtainable (121) The technic of application and the after-care are exacting and time-consuming Furthermore, it demands better healing qualities on the part of the patient than do other grafts As it necessitates considerable pressure, it is apt to fail on a yielding mobile base The site from which it is taken requires some kind of closure, thus, in case the wound is too large to permit of direct approximation of the edges, an additional problem is presented

Despite these objectionable features, the full thickness graft occupies a place that cannot be filled by any other type of transplant Its natural appearance makes it the graft of choice in replacing losses in areas where the final cosmetic result is a consideration, and for this reason it finds wide application for the covering of facial defects In addition, the ability of this type of graft to carry hair renders it especially useful

in the replacement of hairy parts, such as the eyebrows, the eyelashes, and the bearded parts of the face. As it provides substantial protection, it is especially indicated for the repair of losses over weight-bearing areas. Because it contracts less than other grafts, it is invaluable in the resurfacing of raw areas around joints after the removal of contracted scars, and in these localities its use is frequently to be preferred to that of a flap For instance, following a loss of tissue on the palmar surface of the hand, a flap, while desirable, would be too thick for functional purposes.

Technic *Preparation of Recipient Area* The area on which the graft is to be placed is aseptically prepared, draped, and anesthetized in the customary manner The

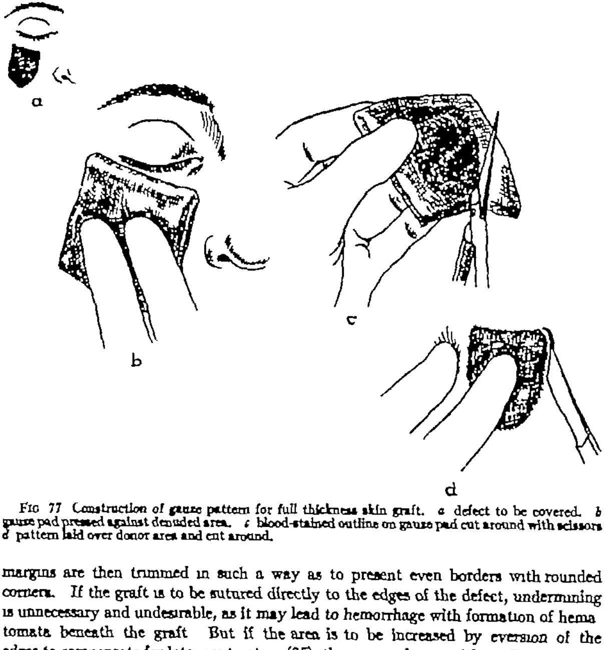


FIG 77 Construction of gauze pattern for full thickness skin graft. *a* defect to be covered. *b* gauze pad pressed against denuded area. *c* blood-stained outline on gauze pad cut around with scissors *d* pattern laid over donor area and cut around.

margins are then trimmed in such a way as to present even borders with rounded corners. If the graft is to be sutured directly to the edges of the defect, undermining is unnecessary and undesirable, as it may lead to hemorrhage with formation of hematomata beneath the graft But if the area is to be increased by eversion of the edges to compensate for later contraction (25), they are undermined for a distance sufficient to allow doubling back (fig 82) Scar tissue, if present, is removed throughout its entire extent to furnish a nutritive bed for the graft. Hemostasis must be absolute. Oozing is controlled by pressure with hot, moist gauze Bleeding vessels if not too numerous, are ligated with # 0000 catgut or fine silk. As previously mentioned, foreign

material beneath the graft interferes with its approximation to the base, therefore, when hemorrhage cannot be controlled except by the use of much ligature material, it is good judgment to delay grafting for a few hours and apply compression to the bleeding surface

The bed having been prepared, a pattern of the defect is made, to be used later in the cutting of the graft By cutting the graft to exact dimensions, it will be possible to subject it to the same degree of tension that it possessed in its original site and thus keep open the endothelial spaces so that they may more quickly take up nourishment If the graft is cut too large, the elastic fibers of the skin contract and close the lymph spaces, and this may lead to edema and to possible sloughing, if cut too small, the tension under which the graft must be sutured will cause its necrosis The pattern may be made in tinfoil, cellosilk, rubber dam, or stiff, paraffin-meshed gauze The perforations in the latter material help to visualize the underlying wound while the pattern is being cut A simple and convenient method consists in pressing a pad of gauze on the raw surface Upon its removal, the outline of the defect, which will be found stained in blood, is cut around with scissors (fig 77) Whatever the material used, it is marked at cardinal points to facilitate orientation of the pattern when the graft is cut

After the recipient area has been prepared and a pattern made, the surface is covered with a gauze compress wrung out of normal salt solution, and this is not removed until the graft is ready to be implanted Before the graft is cut, the personnel effect a change of apparel, and fresh sterile instruments are supplied so as to prevent the carrying of infection from the recipient to the donor area

Securing of Graft Inasmuch as full thickness grafts are used principally on exposed surfaces, the choice of donor area with regard to color, sheen, texture, and hairiness is especially important, and since scarring of the donor site is inevitable, the graft should be taken, whenever possible, from a location where the scar will be inconspicuous and preferably where there is sufficient laxity of tissue to permit of the approximation of the edges of the wound after the graft has been removed

The donor area is aseptically prepared, draped, and anesthetized, the pattern of the defect is laid on the skin, oriented in accordance with the markings previously made, and outlined accurately either with the point of a toothpick dipped in methylene blue or in brilliant green, or scratched around with the point of a small sharp knife, care being taken not to stretch the skin

The graft may be removed either with or without the subcutaneous fatty layer If skin alone is to be raised, a nick is made at a convenient point on the margin of the proposed graft, and a corner is lifted up with a small dural hook, or, better, with a fine silk traction suture which may later serve to anchor the graft in its new location With a sharp knife, the blade directed toward the skin, the separation is made along the plane of junction between the subcutaneous tissue and the skin, a technic similar to that for raising skin in the dissecting room being employed (fig 78) Scissors are best avoided, as they pinch the blood vessels and thus impair the viability of the graft. As the dissection proceeds, additional hooks or sutures are placed at cardinal points to hold the graft under the desired tension For large grafts, the freed skin, doubled on itself, raw surface to raw surface, may be seized between the thumb and forefinger of the left hand Webster (354) has devised a special instrument (fig 79) to facilitate the removal of these grafts It consists essentially of a metal roller grooved

in the center with a needlelike projection to catch and hold the graft. As the skin is separated it is rolled on the cylinder Cutting the graft above the subcutaneous layer eliminates the need of subsequent trimming of its under surface, but the procedure takes a long time if done carefully, and if done carelessly, buttonholing of the graft is likely In addition, it leaves on the base of the wound a layer of fat which forms an obstacle to closure In view of these drawbacks, many surgeons prefer to cut the graft and the subcutaneous layer in a single block (349, 365) When the graft has been removed it is laid, fatty surface up, over the fingers of the left hand, and with a pair of curved scissors the fat is trimmed away until the under surface of the graft appears white and stippled with little pits (fig 80) This method is easy and rapid, although the trimming tends to traumatize the graft

The graft will shrink to nearly half its original size but, if cut to pattern, it will stretch to cover the defect when sutured in place

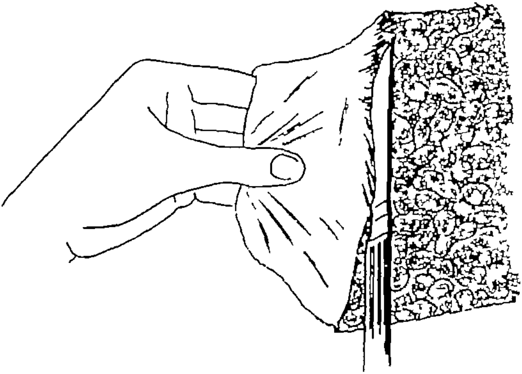


FIG 78. Removal of full thickness skin graft without inclusion of subcutaneous tissue.

Placing of Graft The graft is picked up with fine dural hooks or by the previously placed anchor sutures and is fitted into the bed prepared to receive it. It is placed in such a way that its tension lines are parallel with those of the surrounding skin, if it is hair-bearing, the direction of its hairs is made to correspond to the direction of those in the recipient area. It is anchored to the wound margins at four or more cardinal points, if sutures have been employed to raise the graft, they are used for this purpose (fig 81) The fixation is then completed by an accurate approximation of the margins of the graft to those of the defect either by a continuous suture, or by interrupted sutures of horsehair or silkworm-gut on a semi-curved eyeless needle with a cutting edge Accurate approximation is important, as it makes for neater scars and provides the graft with an additional source of blood supply from the wound edges. If the graft has not already been perforated, a few stab holes are made in it, and a cylinder of gauze is rolled over its surface to express any secretions or air which, if

left beneath the graft, may interfere with its adherence If the graft is placed on an exposed area, the perforations had best be omitted, as each stab hole leaves a tiny scar

Dressing When the operation is completed, a pressure dressing is applied and the part immobilized On the eighth to tenth postoperative day the dressing is taken down, the sutures are removed, and another pressure dressing is applied for a period of 5 or 6 days

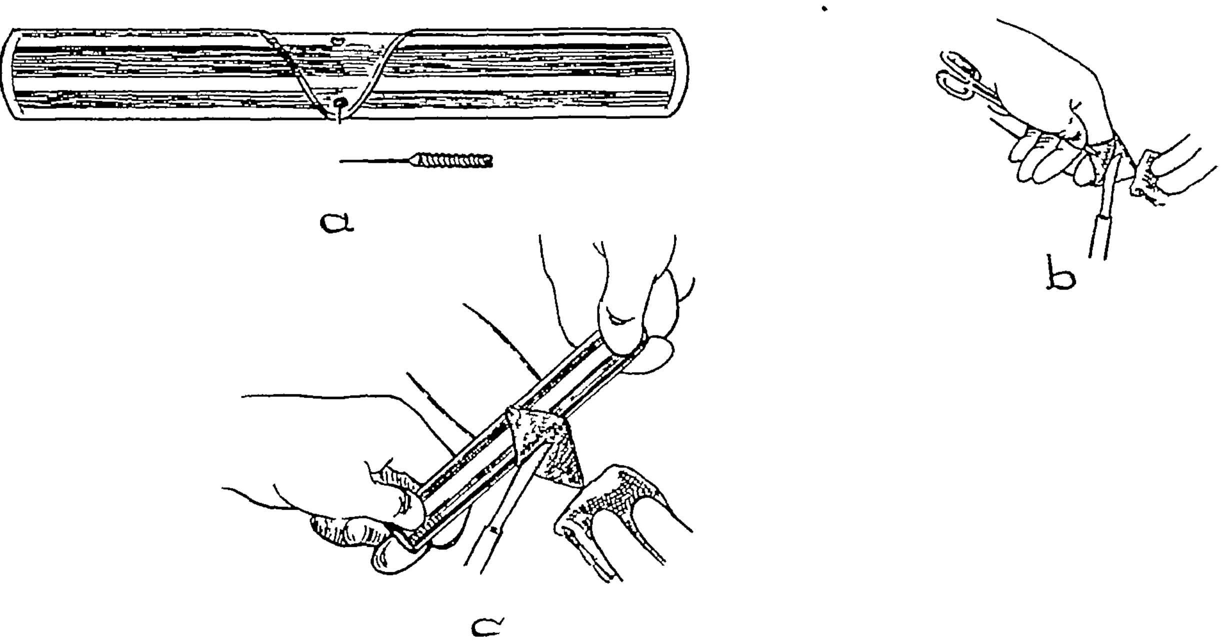


FIG 79 Webster's method for removal of full thickness grafts *a*, grooved metal cylinder (skin roller) and adjustable needle for picking up tip of graft *b*, corner of graft raised *c*, graft caught on needle of cylinder and rolled as dissection proceeds

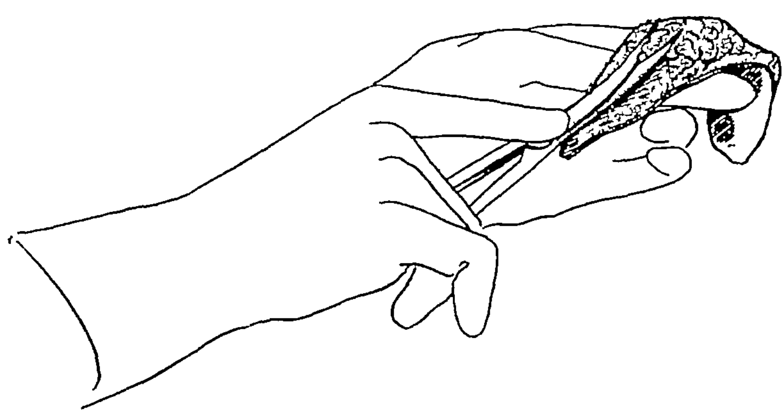


FIG 80 Trimming of full thickness skin graft Subcutaneous tissue trimmed away, until under surface of graft appears white and stippled with little pits

The donor wound is undermined and its margins approximated directly if possible If direct closure cannot be obtained without causing undue tension, the denuded area is covered with a razor graft and a pressure dressing applied

Small Deep Grafts

Since Reverdin's report on "greffe épidermique" in 1869, small grafts have been studied by many workers In 1914 Davis (72) introduced "the small deep graft"

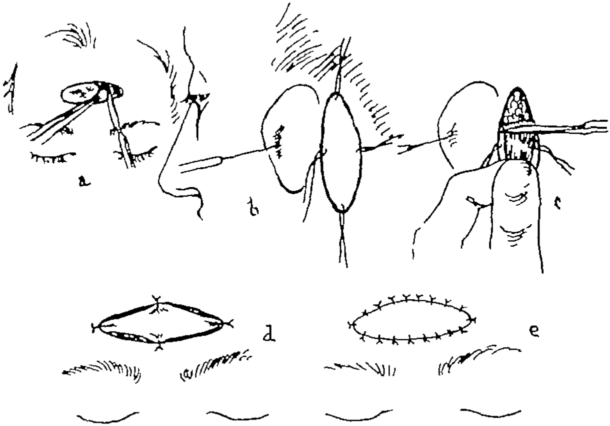


FIG. 81. Application of full thickness graft to forehead defect. *a*, scar on forehead removed and used as pattern for graft. *b* graft outlined to scar pattern in retro-auricular region. Anchor sutures in place. *c*, graft raised. *d* graft secured to forehead defect by completing previously placed anchor sutures *e*, marginal suturing completed.

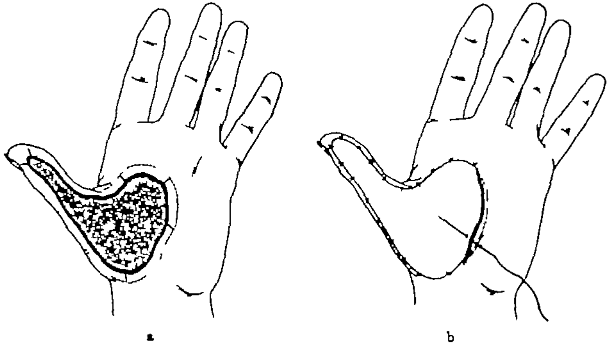


FIG. 82. Method of compensating for contraction following skin-grafting, by increasing raw surface of area to be grafted. *a*, shaded area indicates denuded surface following excision of scar Dotted line shows extent of undermining, to increase raw surface area. *b* undermined rim of skin doubled back, skin surface to skin surface, and graft sutured in place. Each suture made to pass through edge of graft, everted skin edge, and then through palmar skin along line corresponding to edge of graft and everted skin. (Blair)

which has since come to take the place of the former. The small deep graft is a cone-shaped section of skin comprising the entire thickness of the corium in the central portion and tapering off toward the periphery to include only the upper layers of the epidermis These minute grafts are in many particulars comparable to the small thin razor grafts of Reverdin They can be laid directly on intact granulations, with a reasonable assurance of "taking," the danger of stirring up infection being thus averted, and the patient being spared the pain and loss of blood occasioned by cutting the granulations preparatory to other methods of grafting Enough grafts can be taken from a small donor area to cover a relatively large surface They differ from small thin razor grafts, however, in that the grafted surface is more solid and resistant, this is probably the feature which caused them to supplant the latter grafts The chief drawback in the use of small deep grafts is the pitted appearance of the grafted area, which prohibits their use on exposed parts, such as the face On cosmetic grounds also there is a prejudice against these grafts due to their proneness to a brownish pigmentation or keloid formation, furthermore, if they are cut from a hairy area, tufts of hair may appear at the points of full skin thickness They also have a tendency to undergo considerable contraction, hence, they cannot be used as a permanent covering over flexor surfaces of joints Then too, their application incurs the risk of infecting sound tissue by reason of the multiple transfer of instruments back and forth from the open wound to the donor area, although with ordinary care this danger is negligible

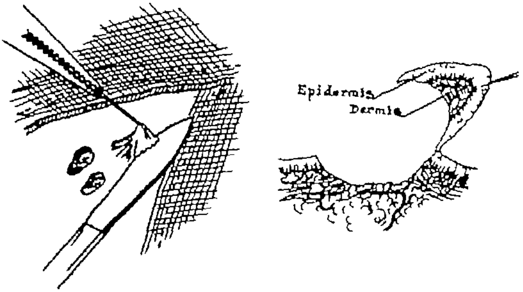
Despite the objectionable features of these grafts, however, the simplicity of their application, the comparatively small donor area required, and their ability to remain viable in the presence of moderate infection have given them a merited popularity Their value is indisputable in the case of patients too depleted to withstand safely the greater disturbance occasioned by other types of grafts, and, like razor grafts, they may be employed as a temporary covering to hasten healing, being subsequently replaced by another type of graft

Technic. Inasmuch as these grafts will remain viable even on intact granulations, the recipient area requires little preparation outside of the usual aseptic cleansing Davis (69) cuts the graft as follows "The patient is placed in a comfortable position on a well padded table The approximate area of the donor site is marked out in the shape of a rectangle or square with brilliant green It is also helpful to the assistant placing the graft to have this marked-out surface from which the grafts are cut lightly stained with this dye Then there is no difficulty in determining which is the epithelial surface A bit of epidermis is picked up on the point of an intestinal needle (this technique was suggested by Agnew in 1874) held in an artery clamp and the skin is raised in the form of a cone The cone is excised with a sharp scalpel (#11 Bard Parker is most convenient), the blade penetrating the skin obliquely downward until a point directly beneath the apex of the cone is reached [fig 83] This manoeuvre is repeated on the other side of the cone, thus obtaining a portion of the entire thickness of the skin in the center and tapering off toward the edge of the graft"

The grafts, when properly cut, are round or oval in shape and vary between 0 4 and 0 5 cm in diameter Larger grafts are inadvisable, as the scarring, both in the donor and in the recipient area is made more conspicuous by their use, furthermore, the circumferential zone of proliferation in larger grafts is absolutely smaller than that around smaller grafts, even though the amount of skin used be the same The

graft, still on the needle, is transferred to the wound at once and is pressed, raw surface down, on the recipient area. In order to guard against the carrying of infection from the granulating area to the donor surface, the needle is flamed before it is returned to the operator or, better, individual sterile needles are used for each graft. Davis prefers to dislodge the graft from the needle onto a folded sterile towel from which it is picked up on another needle by an assistant and placed on the recipient surface. This procedure not only reduces the possibility of transferring infection, but removes any blood which may be on the raw surface The grafts are cut in vertical rows, beginning below and running upward in order to keep the field free of blood. Between the pits there should be left a strip of undisturbed epithelium 10 mm. wide so as to facilitate the healing of the donor area

The grafts are placed on the recipient area in rows, raw surface down (fig 64-b) Although the epithelium from each graft will proliferate over an area of 1 to 2 cm,



a b

FIG. 63 Removal of small deep grafts a cone of epidermis raised on point of needle and sliced obliquely with scalpel. Grafts should average 0 4 to 0.5 cm. in diameter b sectional view showing depth at which graft is cut. For details, see text. (Davis)

yet in order to insure stable healing, they should not be placed at greater distances than 0.5 cm from one another, otherwise the intervening granulation tissue may become so exuberant as to inhibit their growth or cause their absorption. When the grafts are placed the thin edges tend to roll under Davis (69) advises that no attempt be made to uncurl them until two or three rows have been applied, at which time he covers the grafted area with a strip of perforated rubber protective about 2.5 cm wide and long enough to extend well over the surrounding skin With a gauze pledget firm pressure is exerted directly downward on the protective causing the grafts to uncurl and to come into contact with the bed The ends of the protective strip may be secured to the skin by means of a few drops of chloroform Additional rows of grafts are placed and another strip of protective is laid in such fashion that it will overlap the one previously applied about one half, like shingles on a roof The manoeuver is continued until the whole raw area is covered. Strips of perforated cellosilk may be used instead of rubber protective and secured to the skin by equal parts of alcohol

and ether Over the protective layer is placed a moist dressing comprising several layers of gauze wrung out of salt solution This, in turn, is covered by a thin piece of sea sponge cut to fit the defect, overlaid by a thicker sea sponge which projects beyond the grafted surface, the whole being secured under even pressure by adhesive plaster, a bandage, or by elastoplast

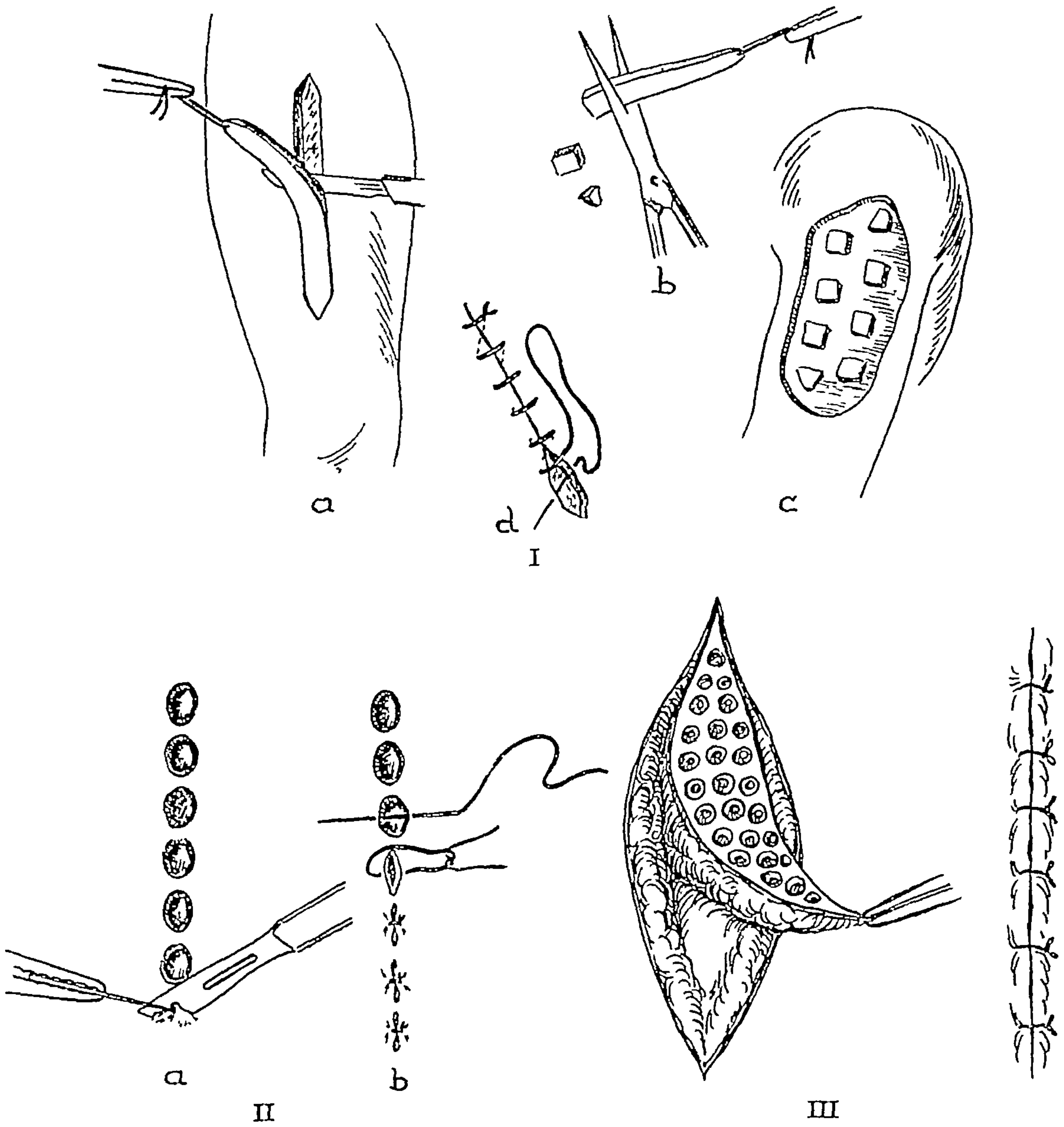


FIG 84 Methods for removing small deep grafts, to facilitate closure of donor site *Ia*, strip of full thickness skin removed *b*, strip divided into small sections *c*, grafts implanted in defect. *d*, donor wound closed by direct approximation (Zee) *IIa*, oval grafts removed in linear succession *b*, each donor wound sutured individually (Conway) *III*, small deep grafts cut from elliptic area to point of complete denudation, wound margins of donor area directly approximated (Goode)

The time of the first postoperative dressing will depend upon the character of the bed When the graft has been placed on a fresh wound, the original dressing may be left on for a week or longer But when applied to an infected granulating surface, it should be changed at the end of 48 hours or sooner, depending upon the amount of discharge

These grafts frequently become viable as early as the second day after their application, appearing as dusky pink spots with narrow halos of newly formed epithelium around the periphery Those which have failed to "take" become white in color and will come away with the dressing in the course of a few days. Should the spread of epithelium be slow and the granulations between the grafts become exuberant, compresses saturated with Dakin's solution may be used after the fifth day without harm to the grafts The after-care and the management of the donor area are the same as for grafts in general (p 129)

Many modifications in the manner of securing the small deep graft have been suggested. Zee (367), in an attempt to minimize the deformity in the donor area, removes a strip of full thickness skin 10 cm. long and 4 cm. wide and closes the donor area, after undermining the margins, by direct approximation (fig 84-I) The strip of skin is divided into small squares of 0.3 to 0 4 cm. each An area of this size will furnish about 30 grafts a number sufficient to cover a bed of 25 square cm. The method has the following objections The small grafts comprise the whole thickness of the skin and will project above the surface upon which they are placed, the base alone coming into direct contact with the wound, thus limiting the surface area capable of receiving a new blood supply In addition, the exposed raw edges may promote exuberant granulations and overwhelm the grafts.

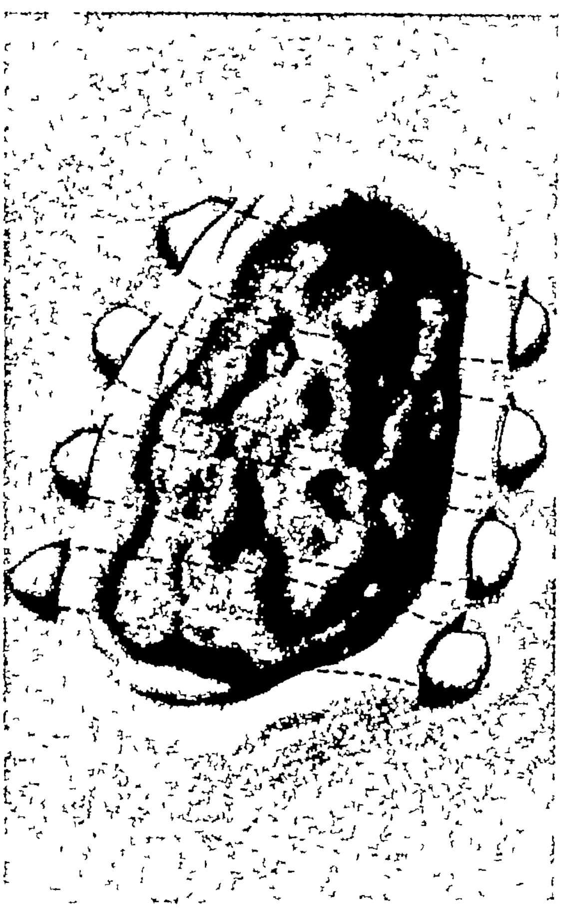
It has been suggested that healing of the donor area may be expedited by a removal of oval grafts in linear succession and by the suturing of each wound individually (59) (fig 84-II) Goode (138, 59) outlines on the donor area an ellipse 3 to 4 cm at its widest part, and from within this figure cuts the grafts to the point of complete denudation (fig 84-III) The wound margins are undermined and approximated directly so as to leave a linear scar

Other Methods of Applying Full Thickness Grafts

(1) **Tunnel Grafts.** Tunnel grafting is a method of introducing full thickness skin grafts beneath the surface When the buried graft has become attached to its bed the overlying tissue is cut through to expose the grafted area. The method was first employed by Parce (267) in 1922, and recorded by Keller (184) in 1930 The principle is based on the Esser inlay graft but the mode of application is somewhat different. While this type of graft has the objectionable quality of producing a poor cosmetic result, is unsuited for covering large defects, and has therefore failed to achieve much popularity, nevertheless it has much to recommend it, as it overcomes many problems encountered in the ordinary method of applying the full thickness graft. The affected surface need not be disturbed by preparatory measures and, even though contaminated the graft beneath it is not likely to become infected, since it is in contact with healthy tissue only Accurate cutting and fitting of the graft are unnecessary, and its buried position enhances its nutrition, protects it from external trauma, and immobilizes it on all sides.

These grafts are applicable in locations where a full thickness graft is required but cannot be employed because of an infected base, for example, in a chronic ulcer over a weight-bearing surface. They are particularly useful in relieving contractures over depressions or folds of the body, such as the axilla, where the application of pressure and immobilization of full thickness grafts would be difficult. In such cases, a graft,

or a series of grafts, is buried at right angles to the line of contracture After the graft has been vascularized the continuity of the overlying scar is broken by an incision over the course of the buried graft, the surface being thus increased and the tension relieved in proportion to the width and the number of grafts employed.



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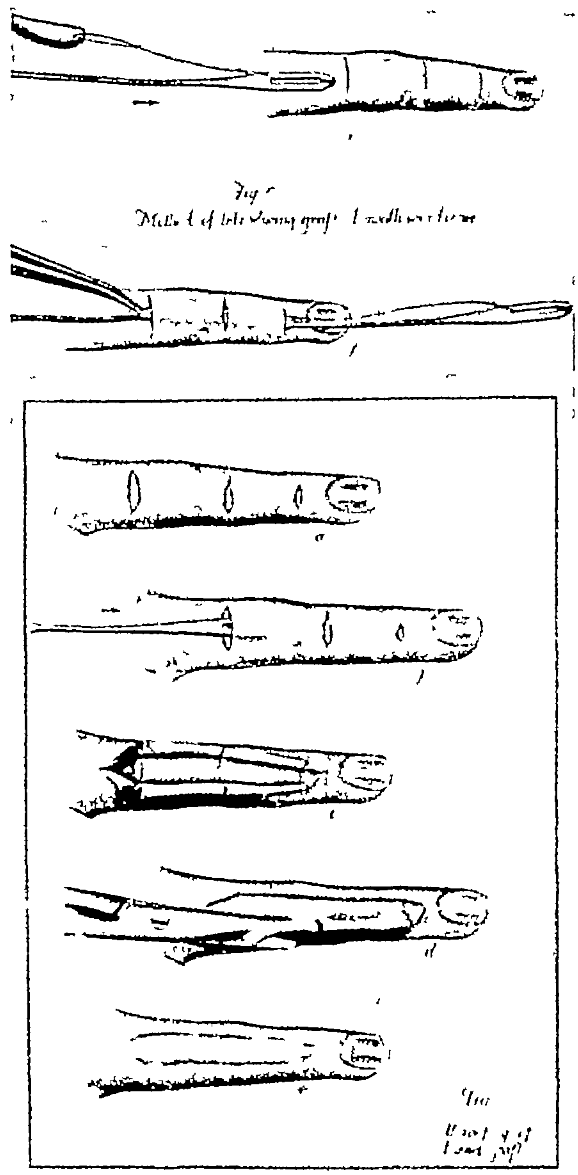


b

Fig 85 Tunnel graft *a*, series of full thickness grafts buried in tunnels beneath granulating ulcer *b*, graft introduced beneath intact surface Roof of tunnel incised longitudinally, and margins of incision rolled back and trimmed (Keller, Ann Surg, Vol 91)

Technic If the surface is a granulating one, a narrow scalpel is passed beneath it, entering at one margin and emerging through the other Into the tunnel thus made a full thickness graft, obtained from an appropriate donor area in the customary manner, is introduced, skin side uppermost, either as a single piece or as a series of separate pieces, the ends being left projecting through the two incisions (fig. 85) A pressure dressing is applied and changed every 3 days thereafter in order to prevent maceration from the secretions Frequently the granulations which form the roof

of the tunnel are spontaneously absorbed, obviating the necessity of an incision to expose the graft.

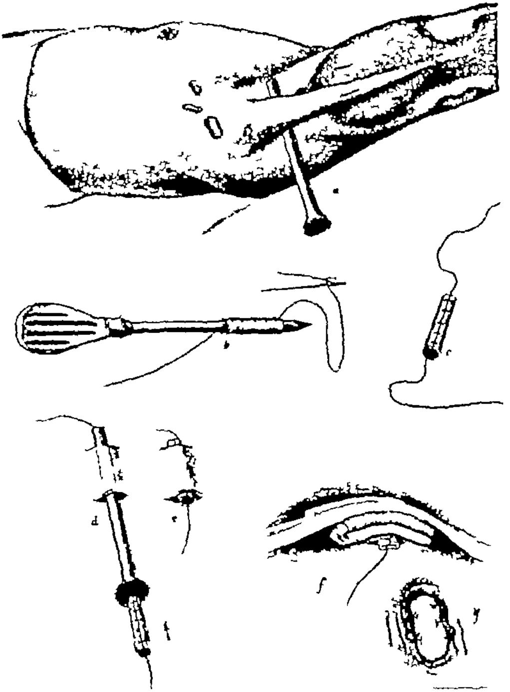
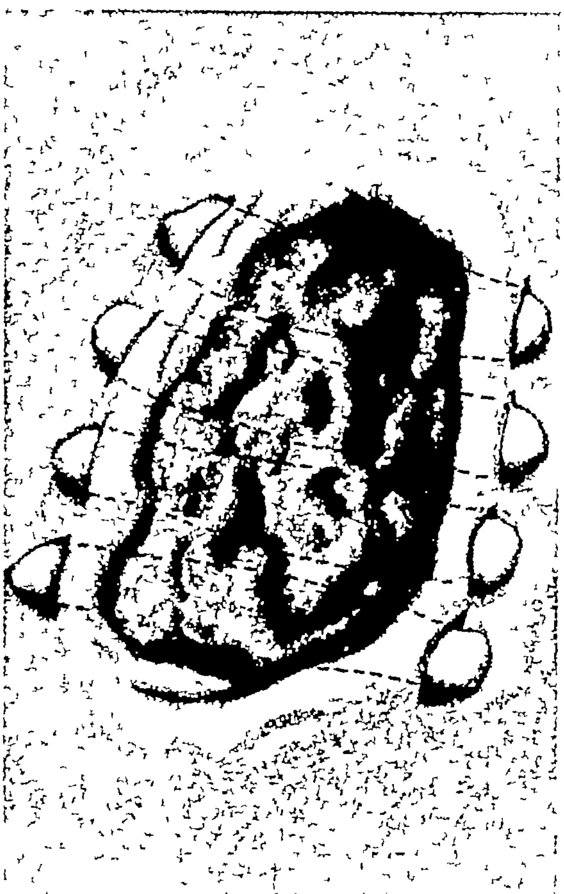


FIG. 86. Use of tunnel graft for relief of cicatricial contraction of groin. *a* trocar and cannula introduced beneath scar *b*, full thickness graft sutured, raw side out, around trocar *c*, view of tubulated graft, with end sutures left long. *d* graft drawn through tunnel. *e*, graft in place. *f*, pressure dressing applied. *g* graft unroofed, trimmed, and sutured to edges of defect. (Keller Ann. Surg. Vol. 91)

In the case of large contracted bands of scar tissue in the axillary folds or in the groin where an especially wide graft is needed, the method employed by Keller is as follows A large trocar and cannula are plunged beneath the scar tissue requiring division, at right angles to the line of contraction The trocar is then removed leaving

or a series of grafts, is buried at right angles to the line of contracture After the graft has been vascularized the continuity of the overlying scar is broken by an incision over the course of the buried graft, the surface being thus increased and the tension relieved in proportion to the width and the number of grafts employed



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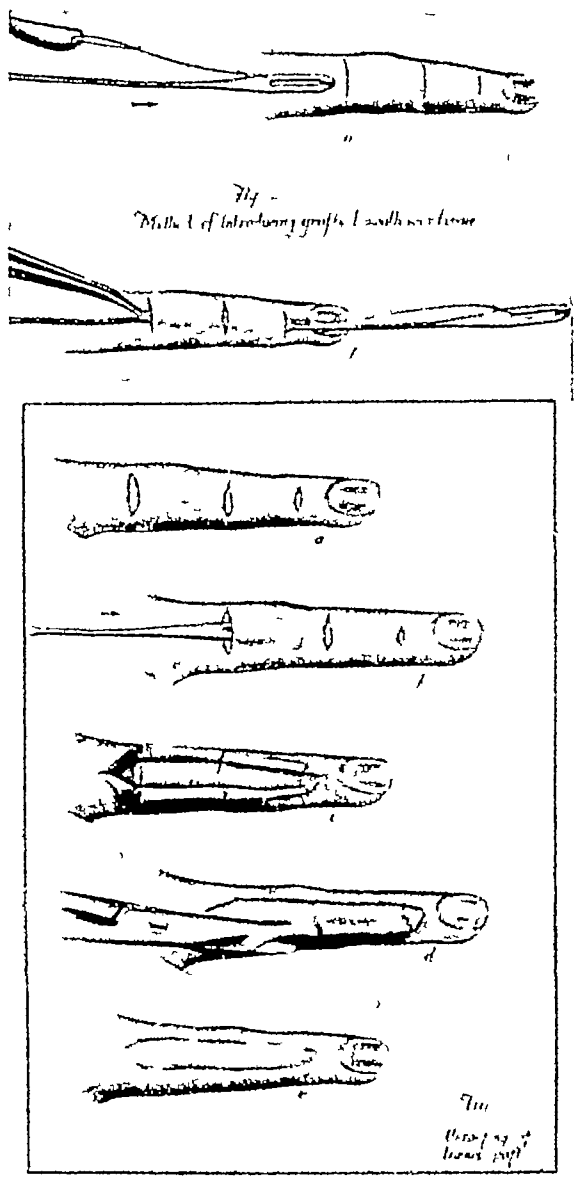

b

FIG 85 Tunnel graft *a*, series of full thickness grafts buried in tunnels beneath granulating ulcer *b*, graft introduced beneath intact surface Roof of tunnel incised longitudinally, and margins of incision rolled back and trimmed (Keller, Ann Surg, Vol 91)

Technic If the surface is a granulating one, a narrow scalpel is passed beneath it, entering at one margin and emerging through the other Into the tunnel thus made a full thickness graft, obtained from an appropriate donor area in the customary manner, is introduced, skin side uppermost, either as a single piece or as a series of separate pieces, the ends being left projecting through the two incisions (fig 85) A pressure dressing is applied and changed every 3 days thereafter in order to prevent maceration from the secretions Frequently the granulations which form the roof

of the tunnel are spontaneously absorbed, obviating the necessity of an incision to expose the graft.

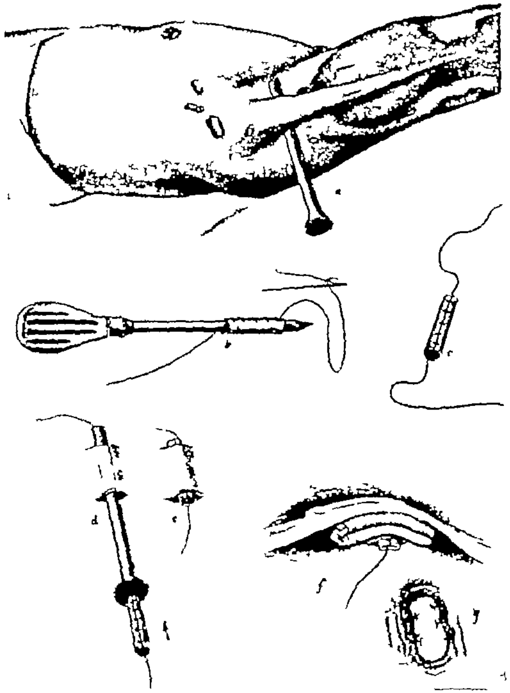

FIG 86 Use of tunnel graft for relief of cicatricial contraction of groin. *a*, trocar and cannula introduced beneath scar *b*, full thickness graft sutured raw side out, around trocar *c*, view of tubulated graft, with end sutures left long. *d*, graft drawn through tunnel. *e*, graft in place. *f*, pressure dressing applied. *g* graft unroofed, trimmed, and sutured to edges of defect. (Keller Ann. Surg., Vol. 91)

In the case of large contracted bands of scar tissue in the axillary folds or in the groin where an especially wide graft is needed, the method employed by Keller is as follows A large trocar and cannula are plunged beneath the scar tissue requiring division, at right angles to the line of contraction The trocar is then removed, leaving

or a series of grafts, is buried at right angles to the line of contracture After the graft has been vascularized the continuity of the overlying scar is broken by an incision over the course of the buried graft, the surface being thus increased and the tension relieved in proportion to the width and the number of grafts employed

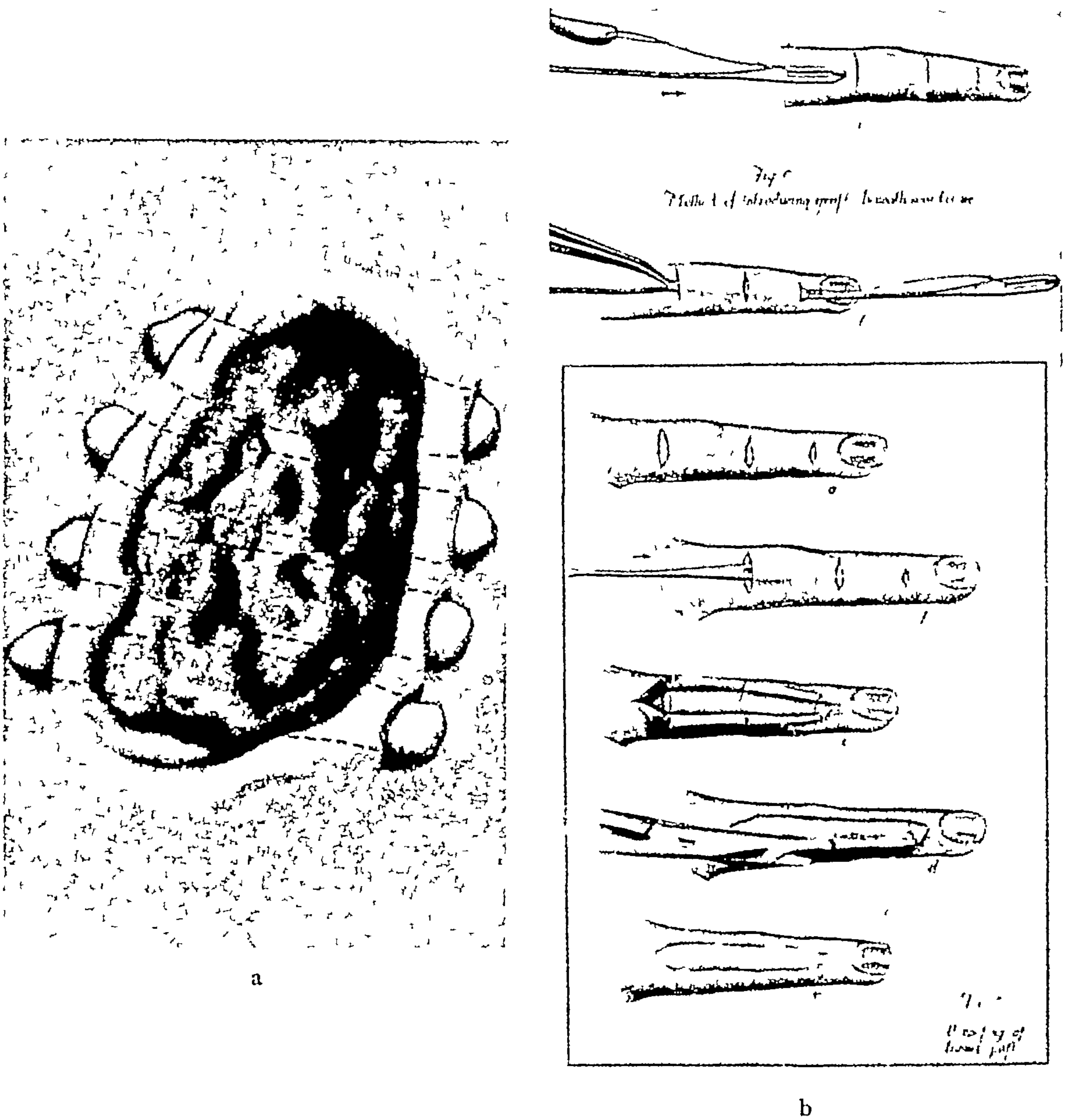

FIG 85 Tunnel graft *a*, series of full thickness grafts buried in tunnels beneath granulating ulcer *b*, graft introduced beneath intact surface Roof of tunnel incised longitudinally, and margins of incision rolled back and trimmed (Keller, Ann Surg, Vol 91)

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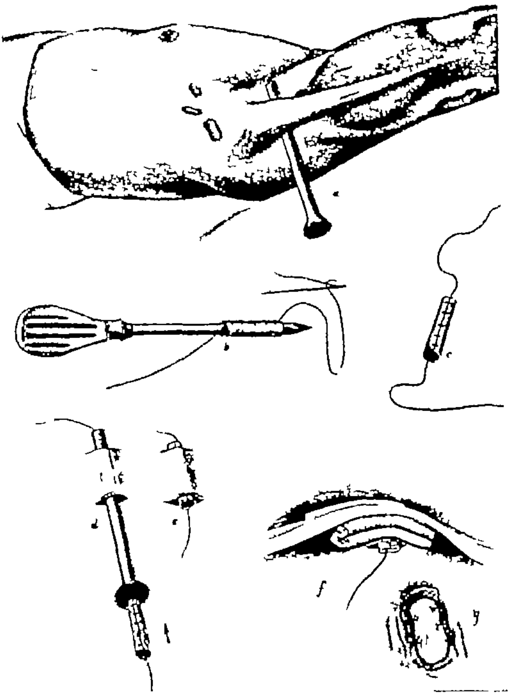

FIG. 86. Use of tunnel graft for relief of cicatricial contraction of groin. *a* trocar and cannula introduced beneath scar *b*, full thickness graft sutured, raw side out, around trocar *c*, view of tubulated graft, with end sutures left long. *d* graft drawn through tunnel. *e*, graft in place. *f*, pressure dressing applied. *g* graft unroofed, trimmed and sutured to edges of defect. (Keller Ann. Surg Vol. 91)

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the cannula in place A graft of full thickness skin is wrapped lengthwise around the trocar, raw side out; its edges are united with catgut so that a tube of skin, like an umbrella cover, encloses the trocar. The end suture is left long, threaded on a long needle, and carried through the cannula to emerge on the skin just beyond the blind extremity of the tunnel Traction is exerted on the thread, drawing the tube of skin through the cannula, which is then removed, leaving the graft in place The part is covered by a pressure dressing which is left undisturbed for 2 weeks At the end of this period an incision is made through the roof of the tunnel immediately over the suture line on the graft, the graft is unfolded, and its edges are trimmed and sutured to the margins of the defect (fig 86)

(2) **Sieve Grafts** The sieve graft, described by Douglas (91) in 1930, is essentially a full thickness graft uniformly perforated with many round openings to correspond with islands of skin left behind in the donor area In principle it is a modification of the small deep graft of Davis Douglas (91) believes that this type of graft fulfils all the requirements of an ideal graft· (1) It can be cut in such a manner that its removal will leave behind a wound capable of rapid healing without need for further grafting, and with only slight scarring, (2) it is able to grow upon a moderately infected surface, (3) it provides complete healing in a reasonably short time, (4) it inhibits scar formation and subsequent contracture—a point especially important in the case of defects over joints, and (5) it produces a pliable skin surface resistant to minor injuries

Technic The recipient area is aseptically prepared, draped, and anesthetized in the usual manner The choice of the donor site, its aseptic preparation, and the manner of procuring the graft are the same as for any full thickness graft, except that perforations are first made in the skin with a steel die, the cutting edge of which is 6 mm in diameter and 1 5 mm deep A graft of suitable size is outlined in methylene blue With the skin held under tension, the operator grasps the die between thumb and index finger, places it at right angles to the skin, and by a twisting motion of the fingers he outlines numerous little cutaneous islands about 1 to 2 cm apart over the surface of the proposed graft. The whole graft is then cut around and raised in the manner already described, care being taken to leave behind the punched-out islands The best way to secure this result is to have the assistant depress each island with a sterile probe while the surgeon is dissecting the surrounding skin When finally removed, the graft with its evenly spaced holes resembles a sieve, and the donor area will be found studded with equally spaced islands (fig 87) By the use of the same technic employed in placing any full thickness graft the transplant, with its numerous round drainage holes, is applied to the recipient area A pressure dressing is applied and the graft is left undisturbed for 2 or 3 weeks At the end of this time the perforations will be found covered with skin, the grafted area resembling the donor site following the removal of small deep grafts The donor area is dressed like any open wound

(3) **Dermal Grafts** A dermal graft is a de-epithelized full thickness skin graft composed of the corium alone or in combination with the basal layer of the epidermis This type of graft was first employed by Loewe (213) in 1913 and has since been used successfully by Rehn (287), Eitner (98), Blair, and others These grafts can be obtained in large sections and are easily manipulated They find their greatest applica-

tion in the building up of depressions beneath the skin, and in this capacity have been found superior to fat grafts in that they more readily adjust themselves to their new location and with less loss from absorption, and thus eliminate the need for overcorrection They are also employed as living suture material and as artificial tendons and ligaments (287), for which purposes they are said to be as dependable as fascia lata. Some of their more specific uses are for the repair of hernias, for the elevation of small saddle defects in the nose, and for the correction of facial depressions (99)

The principal drawback to the use of these grafts is the danger of infection owing to the impossibility of sterilizing the skin, although many surgeons familiar with the

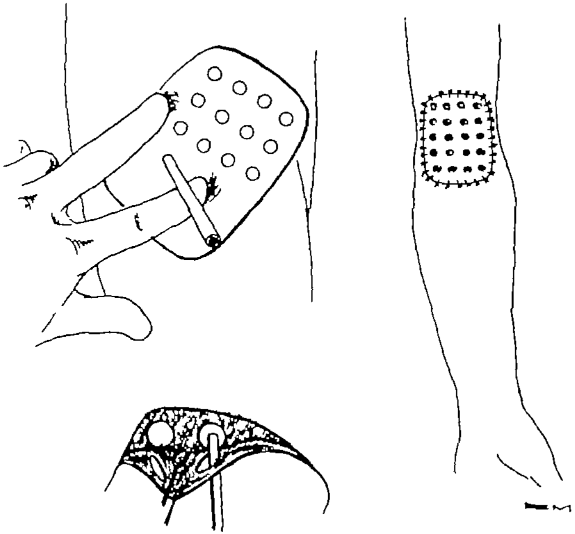

FIG 87 Sieve graft. Donor area perforated with steel die, while skin is held under tension. Graft raised, showing small cutaneous islands left on raw area Sieve graft in place on recipient site. (Douglas)

method claim that this danger has been overemphasized. Another objection is their tendency to undergo cyst formation due to the retention of glandular structures As far back as 1887, Reverdin (293) noted that bits of epidermis deposited in the corium were capable of developing cysts. Similar findings were later reported by Kaufmann (180) Garré, and Davis and Traut (77) following the transplantation of free whole thickness skin grafts into the abdominal muscles of dogs. Recently, experiments have been carried out by Peer and Paddock (272) who placed sections of such grafts

beneath the chest skin of humans and removed them at intervals of 7 days to 1 year. Examination of the sections showed a complete disappearance of sebaceous glands and hair follicles, sweat glands were found in the 1 year sections but showed definite degenerative changes, in the early specimens remnants of epidermis incompletely removed showed small cysts, but these were absent in the later sections

Technic The area of skin selected is shaved and sterilized. The graft may be obtained in any one of the following ways (1) A portion of full thickness skin of the desired size is excised and stretched on a board The epithelium is then sliced off with a knife in the same manner as one would cut a razor graft (43) (2) The epidermis

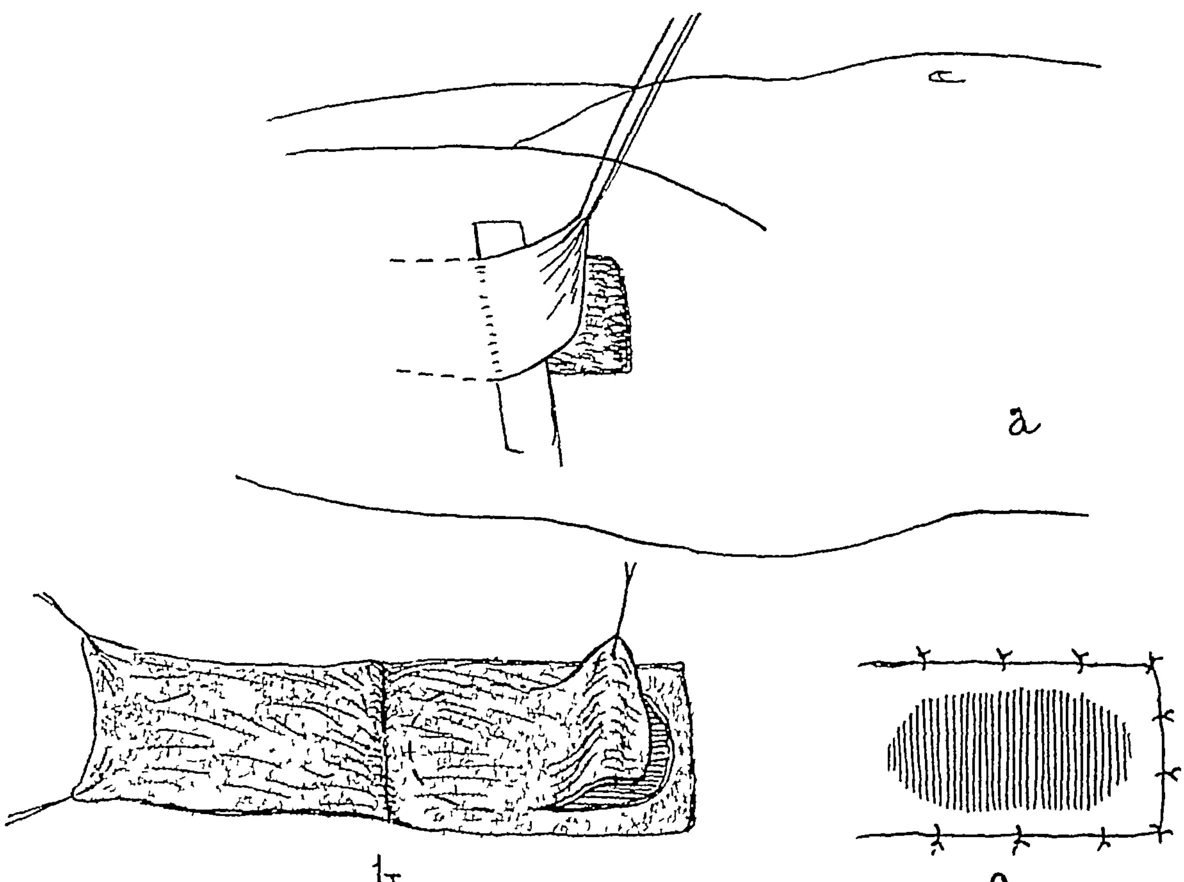

Fig 88 Technic for procuring dermal graft *a*, thin layer of epidermis raised with skin-graft knife and reflected *b*, dermal graft outlined and removed *c*, epithelial flap sutured back in place over denuded area

may be shaved off prior to raising the graft (3) A more economical method is to raise with a skin-graft knife a large thin razor graft, leaving it hinged at one end. The dermal graft is then cut out together with some underlying fat, after which the flap is laid back on the raw surface and retained by 3 or 4 marginal sutures (fig 88).

The de-epithelized graft, fatty surface outward, is inserted into a previously prepared subcutaneous pocket and fixed in place with a few interrupted silk sutures If the inclusion of fat is objectionable, the required bulk may be obtained by the lay of several strips over one another and tying them together with a mattress-suture insertion

Mucous Membrane Grafts

The use of mucous membrane transplants is necessarily restricted, inasmuch as the supply of available material is limited and the membrane is so situated as to render asepsis difficult. The first report of success with this type of graft was made by Wolfe (362) (1872), who transferred bits of conjunctiva from one part of the eye *to another* Hirschberg (1874) used buccal mucous membrane for the same purpose.

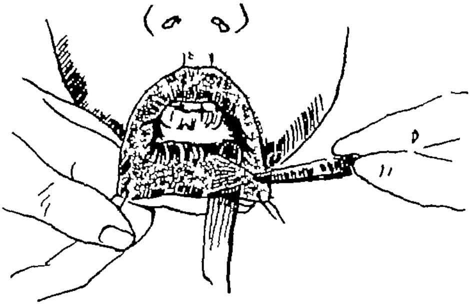

Fig 89 Removal of mucous membrane graft from inner surface of lip with razor Same technic employed as for removal of skin graft of equal thickness (Davis)

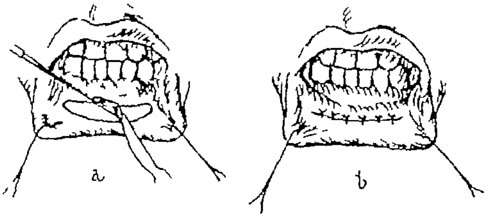

Fig 90 Removal of mucous membrane graft from inner surface of lip with knife. *a*, pattern out lined by incision, and graft removed with knife in same manner as full thickness skin graft. *b* wound closed. Same technic is employed in obtaining grafts from cheek and vagina. (Davis)

Wolfler repaired a urethral stricture with strips of mucosa taken from a prolapsed rectum. Virchow was the first to suggest that losses of mucous membrane be replaced by skin. He stated that following transplantation these grafts assumed the characteristics of mucous membrane Thiersch (337) took issue with this statement and cited a case in which he had used a skin flap to reconstruct a soft palate. So much hair grew upon the part that the patient was compelled continually to shave the inside of his mouth

Mucous membrane finds its greatest usefulness in the replacement of small defects about the vermilion border, the urethra, and the conjunctiva of the intact eye (p 854) In the latter case, skin grafts are inapplicable no matter how thinly they are cut, since the proliferation of epithelium and the tendency of the graft to grow hair may lead to irritation, ulceration, and pannus formation

Mucous membrane for grafting purposes is usually obtained from the inside of the lip and cheek, from the lining of the turbinates, and from the vagina The technic of its removal and application is essentially the same as that for a skin graft Briefly, the cicatricial tissue overlying the defect is removed, and a pattern of the area to be grafted is made in cellophane and placed on the donor area With a fine-pointed knife the pattern is cut around, and the graft thus outlined is dissected off with a scalpel or shaved off with a miniature razor (figs 89-90) After hemorrhage has been controlled, the defect in the donor area is closed The raw surface of the graft is trimmed down until all adherent submucous tissue has been removed The graft is then sutured into position and a pressure dressing applied The application of mucous membrane grafts to special areas, such as the conjunctiva, will be described in the respective sections

Keratoplasty

The restoration of vision in an eye blinded by a corneal opacity, but otherwise healthy, has challenged the interest and imagination of surgeons from earliest times In 1789 de Quengsy suggested the replacement of an opaque cornea by a window of glass Similarly, Van Millingen (345) (1894), after removing a segment of the opaque cornea, covered the aperture with a contact glass shaped like an artificial eye Baker (13) employed for the same purpose a glass button shaped like a collar stud Dimmer (85) formed an artificial cornea of transparent celluloid and held it in place by flaps of corneal tissue Himley (161) in 1813 suggested the transplantation of corneal tissue, and in the next few years many such attempts were made But without anesthesia, asepsis, and adequate instruments, all early operations necessarily failed, and the procedure soon came to be considered impossible In 1878, however, von Hippel (163) aroused new interest in the subject by demonstrating at the International Congress in Heidelberg two successful corneal grafts in rabbits With a specially devised trephine he removed a full thickness disk 4 to 5 mm in diameter from the opaque cornea of the recipient eye and replaced it by a corneal transplant of the same size, removed from the donor eye in a similar manner The transplant was held in place by pressure of the closed lids Since von Hippel's memorable demonstration, keratoplasty has developed from a purely experimental into a practical procedure, largely through the efforts of Castroviejo (50) in the United States, and of Elschnig (101), Filatov (110), Thomas (341), and others abroad While the number of successful results are still comparatively few, and an entirely transparent graft is exceptional, nevertheless, with modern technic and in properly selected cases there is a reasonable expectation that corneal transplantation will restore vision to such a degree that a patient, previously led, may get about without assistance Generally speaking, 25 per cent will recover good vision and 50 per cent will show some improvement Where the opacity is due to interstitial keratitis, favorable results may be expected in 75 per cent of cases Elschnig reported 46 per cent of successes in 174 operations,

Filatov cites 96 cases, of which 43 per cent were successful, Castroviejo shows 81 per cent, and Thomas 83 per cent of good results. The comparatively low percentage of successes of the first two surgeons is explainable by the fact that their reports include results of early operations performed before the technic was well established.

The actual transplantation of corneal tissue offers no great difficulty With ordinary technic, these grafts remain viable in 80 per cent of cases. The problem is to maintain their transparency, and in an effort to accomplish this, three types of transplants have been experimented with, namely

(1) **Massive Full Thickness Corneal Grafts.** The whole cornea is transplanted with or without 2 or 3 mm. of the surrounding conjunctiva. This form of transplant has been abandoned as it was found invariably to become opaque (107, 42, 100, 186)

(2) **Circumscribed Split Corneal or Lamellar Grafts.** A circumscribed area of the superficial lamella of an opaque cornea is removed and replaced by a similar thickness of corneal tissue. The operation is easy to perform and there is little likelihood of the intra-ocular structures becoming displaced, but connective tissue inevitably forms at the base of the transplant and defeats its purpose The method was presented in 1888 by von Hippel (162) as a modification of his original technic. With a trephine he removed a 4 to 5 mm. disk comprising the superficial layers of the cornea and replaced it by an equally sized disk of healthy corneal tissue Many attempts were later made with this method (347), most of which proved unsuccessful (248, 216, 246), Fuchs reported 30 operations and observed improvement in only two

(3) **Minute Full Thickness Grafts (Circumscribed Penetrating Keratoplasty)** A small area, 4 to 5 mm in diameter, of the full thickness of the opaque cornea is removed and replaced by a healthy corneal transplant of corresponding size This is generally admitted to be the only dependable method of corneal grafting and was first employed in 1824 by Reisenger (288) It received little attention, however until 1878, when von Hippel (162) devised a trephine which made it possible to cut the bed and the graft of the same dimensions.

Source of Corneal Transplants. The graft may be autoplastic, obtained from healthy cornea of the same eye or from a fellow blind eye with a usable cornea. Morax (246) interchanged lamellar corneal disks in the same eye in such a way as to make the clear disk lie over the pupil and the opaque one at the periphery of the cornea. Kraupa (193) operated in a similar manner, but used full thickness cornea. Friede (118) raised a flap consisting of the entire thickness of the cornea with the opacity at its center and the transparent zone at the periphery He then rotated the flap 180 degrees so as to place the transparent zone in the pupillary area and the opaque portion on the periphery

While autoplastic transplants offer the best prospects of success unfortunately conditions under which they can be obtained seldom exist. Homoplastic grafts are therefore the ones most commonly employed. They may be obtained (1) from an eye with a healthy cornea, enucleated as a result of trauma or neoplasms (Elschnig believes that the donor eye need not necessarily be healthy, provided the cornea is transparent, and employs donor eyes which have been removed for absolute glaucoma and also those which have undergone atrophy), (2) from stillborn infants, and (3) from the eyes of cadavers Filatov (110), director of the Ukrainian Institute of Experimental Ophthalmology, uses grafts from the eyes of patients who have died

by their own hand or as a result of an accident. He rules out syphilitics by serologic tests The eye is enucleated within a few hours after death and may be used immediately or preserved in the citrated or freshly clotted blood of the donor at a temperature of 4 to 6° C for as long as 20 to 56 hours Filatov (118) states "I can say with perfect assurance that corneas taken from the eyes of cadavers, even those which had been conserved for a long time, proved to be just as good as those taken from living persons After eyes have been obtained from a cadaver they are washed in brilliant green solution, 1·2000, and put with the corneas upward in a glass jar with a tightly fitting cork I have also tried to keep them in citrated blood from the person from whom they were obtained, according to Professor Judin's advice My observations confirm those of Magitot (225) who in one of his operations succeeded in obtaining a transparent taking of a cornea removed from the eye of a cadaver, preserved in hemolized blood of the cadaver and kept for eight days at a temperature of 4°C Magitot was also successful in using the cornea of an embryo Thus I may say that the using of transplants from cadavers' eyes has a good prospect of success This is analogous to the problem of blood transfusion from dead bodies, which was taken up by Shamov experimentally, and which gave splendid results in the work of Judin (Moscow) "

In the selection of a donor, preference should be given to a young individual Blood grouping is unnecessary, as it seems to have no effect on the outcome of the procedure As in the case of other forms of grafting, transplants taken from lower animals have invariably failed and at present do not seem to justify further trial

Indications for Corneal Transplantation. In properly selected cases corneal transplantation is a fairly successful operation, but unfortunately its field of applicability is necessarily limited to eyes normal but for the presence of a corneal opacity Such opacities are likely to occur only as the result of burns, interstitial keratitis, and healed ulcers Prospects of success are brightest when the eye shows a fair degree of light projection (Elschnig (101) states that he operates only "when good light perception and projection (candle at 6 meters) indicate a normal retina and optic nerve"), and where the anterior chamber and conjunctiva are normal, and some transparent corneal elements still remain Castroviejo (50) classifies favorable cases for corneal grafting as those in which: "(1) there is normal intra-ocular tension, (2) the diseased ocular tissue is limited to the cornea, (3) the leucoma is not very dense, although sufficient to cause considerable impairment of vision, and (4) there are areas of clear or slightly scarred cornea surrounding the graft " The operation offers little chance of success in cases of dense total leucoma, anterior synechia, staphyloma, iridocyclitis, aphakia, and glaucoma, and is obviously useless in the case of optic atrophy However, it frequently happens that preliminary operations on these conditions pave the way for subsequent successful grafting For instance, synechia may be divided, staphyloma excised, and increased intra-ocular pressure reduced

Preoperative Considerations The patient is examined as before any surgical operation for the detection of any constitutional disease or foci of infection The donor is likewise examined for the presence of transmissible diseases such as syphilis Before embarking upon operation, all deformities about the eyelid must be corrected, and pathologic lesions in the eyeball itself, such as attachment of uveal tissue to the cornea, attended to If infection is present, the operation must be postponed for a year or two The condition of the optic nerve and retinal function are determined

by a test of the accuracy of the patient's projection of light, inability to perceive the movement of the hand before the eyes contraindicates grafting The depth of the anterior chamber and the transparency of the lens must also be investigated Cultures are taken from both the recipient and the donor eye, if hemolytic pyogenic organisms are found, the operation is best postponed.

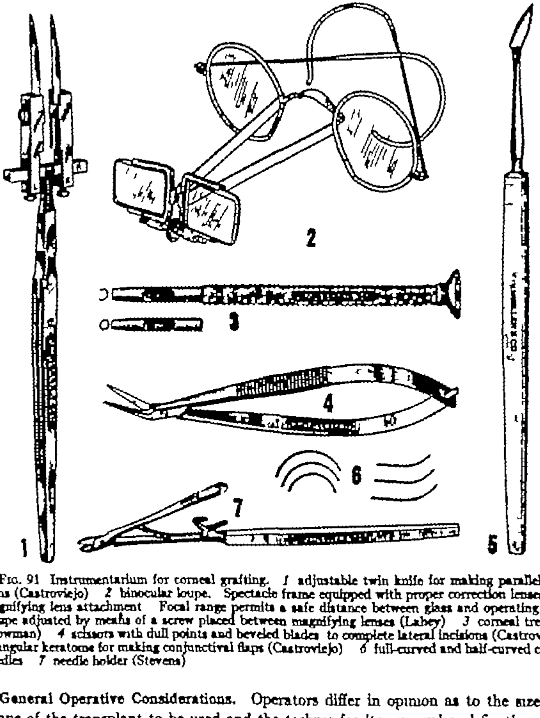

FIG. 91 Instrumentarium for corneal grafting. *1* adjustable twin knife for making parallel inci sions (Castroviejo) *2* binocular loupe. Spectacle frame equipped with proper correction lenses and magnifying lens attachment Focal range permits a safe distance between glass and operating field. Loupe adjusted by means of a screw placed between magnifying lenses (Lahey) *3* corneal trephine (Bowman) *4* scissors with dull points and beveled blades to complete lateral incisions (Castroviejo) *5* angular keratome for making conjunctival flaps (Castroviejo) *6* full-curved and half-curved cornea needles *7* needle holder (Stevens)

General Operative Considerations. Operators differ in opinion as to the size and shape of the transplant to be used and the technic for its removal and fixation. All agree however that the size should range from 4 to 5 mm., for if it is larger, there is danger that the transplant may become incarcerated in the iris and, if smaller, the adhesions which form between the graft and the host may destroy its transparency Thomas (340) suggests that the graft be cut somewhat smaller than its bed to compensate for its subsequent swelling Most surgeons prefer circular to rectangular

grafts on the grounds that in the latter the corners have a tendency to protrude and impair the viability of the transplant In order to prevent the graft from slipping from its bed into the anterior chamber and to enhance its nutrition by a greater surface contact, its margins are beveled Elschnig (101), however, avoids beveling in the belief that it diminishes the posterior visual aspect of the graft, renders fixation difficult, and increases the area of the linear scar

The instrument usually employed for the cutting of the graft is a trephine Thomas (339) operates as follows With a modified von Hippel trephine a disk is outlined in the opaque cornea 4 to 4 5 mm in diameter The trephine is tilted to form an angle of 45°, and the cornea is cut through at one point A pair of scissors is then introduced through the opening thus made and the remaining margins of the circle are cut in a shelving manner so that the inner surface of the graft is smaller than the outer To eliminate the danger of injury to the iris and lens, Filatov (111) inserts a plate of ivory or celluloid across the anterior chamber prior to trephining With a Graefe knife he makes two incisions outside of the cornea, the outer 6 mm and the inner 4 mm long

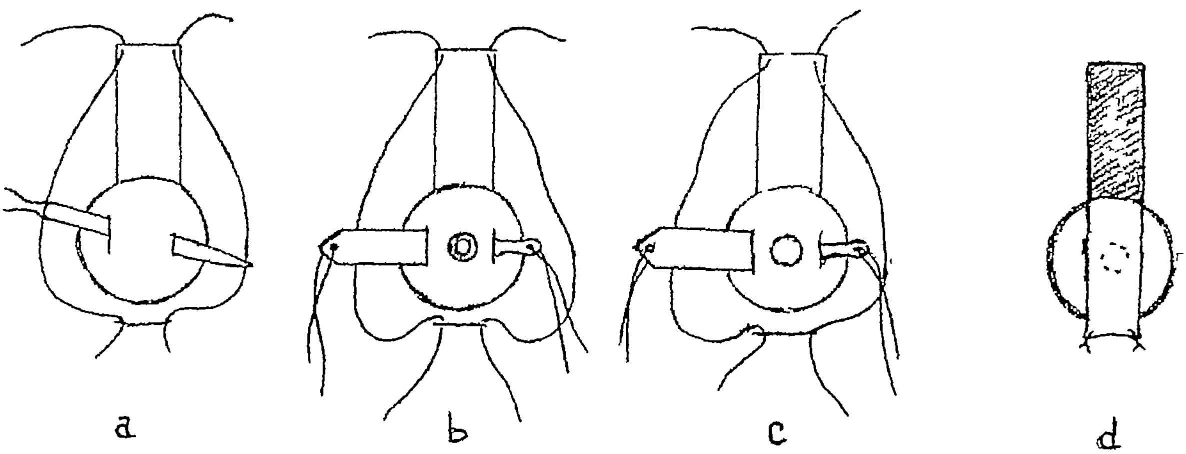

FIG 92 Filatov's keratoplasty *a,* conjunctival flap outlined, and sutures passed Leucoma incised *b,* ivory plate passed between cornea and iris, and corneal disk removed *c,* corneal transplant in place over trephine opening *d,* spatula removed Corneal graft covered with conjunctival flap

and through these he passes the plate between the cornea in front and the iris and lens behind On this support he trephines the cornea in the usual manner (fig 92) Castroviejo (50) cuts the graft with a specially constructed double-bladed knife with adjustable blades and a specially bent keratome, in the belief that with these instruments the graft can be cut more evenly and cleanly than with trephine and scissors

To immobilize the graft, various kinds of sutures and conjunctival flaps are employed Elschnig (101) passes one needle of a double-armed suture of black silk through the conjunctiva at a point about 1 5 mm from the limbus and the other at a distance of 1 to 2 mm from it (fig 93-A) The needles are then made to take a bite of the conjunctiva at similar points below the cornea, so that when the ends are put on tension the two strands will lie parallel to each other over the transplant Thomas (341) retains the graft by cross-stitching through the opaque cornea adjoining the graft, the sutures passing over the surface of the latter in the form of a Maltese cross, and the knots being so placed that they do not lie on the graft or near its margins (fig 93-B)

While fixation by sutures permits of early inspection, it has the objectionable feature of bringing a foreign body into contact with the graft To overcome this objection,

the use of various forms of conjunctival flaps has been suggested. These flaps not only serve to fix the graft in place but have the additional advantage of protecting the corneal epithelium from damage and possibly also assist in nourishing the graft. They have the disadvantage, however, of concealing the graft and making it impossible to determine whether or not it has been dislodged. Castroviejo (50) covers the grafted area with a conjunctival flap obtained by undermining the conjunctiva from below the limbus, and attaches it to the conjunctiva above the transplant (fig 93-D) Filatov (110) holds the graft in place by a ribbon shaped flap of conjunctiva turned down from above so that the epithelial surface of the flap covers the epithelial surface of the graft. A flap of conjunctiva 5 mm broad and 10 mm long, with its pedicle at the limbus is dissected from above the cornea. A suture is passed through each upper angle of the flap and through corresponding points in the conjunctiva below the cornea. These

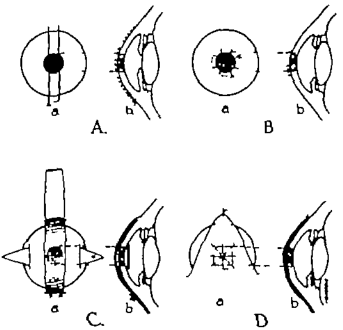

FIG. 93 Various methods for immobilization of corneal grafts. *A* two strands of double-armed suture of black silk lying parallel across graft (Elschnig) *B* threads cross-stitched above cornea in form of Maltese cross (Thomas) *C* ribbon-shaped conjunctival flap turned down from above to cover graft (Filatov) *D*, conjunctival flap reflected from below and attached to conjunctiva above (Castroviejo) (Castroviejo Surg Gynec. & Obst. 1937)

sutures are held aside and not completed until the graft is in place (fig 93-C) If, for some reason a conjunctival flap cannot be used, Filatov places a sheet of egg membrane, inner surface down over the graft and fixes both the graft and the membrane by a suture after the manner of Elschnig Rycroft (301) obtains immobilization by drawing a conjunctival flap tent fashion over the entire graft. The conjunctiva is incised around the limbus and is undermined to the equator with blunt-pointed scissors A pursestring suture of #1 silk is passed 1.5 mm. from the cut edge it is inserted in such a way as to render the aperture eccentric so that when the suture is tightened it will not come in contact with the graft.

Irrespective of the method used to fix the graft, provision must be made for fixation at the time the recipient area is prepared, so that there will be no delay in immobilizing the graft after it is in place.

Operative Technic. The special instruments for corneal grafting include a Hippel

grafts on the grounds that in the latter the corners have a tendency to protrude and impair the viability of the transplant In order to prevent the graft from slipping from its bed into the anterior chamber and to enhance its nutrition by a greater surface contact, its margins are beveled Elschnig (101), however, avoids beveling in the belief that it diminishes the posterior visual aspect of the graft, renders fixation difficult, and increases the area of the linear scar

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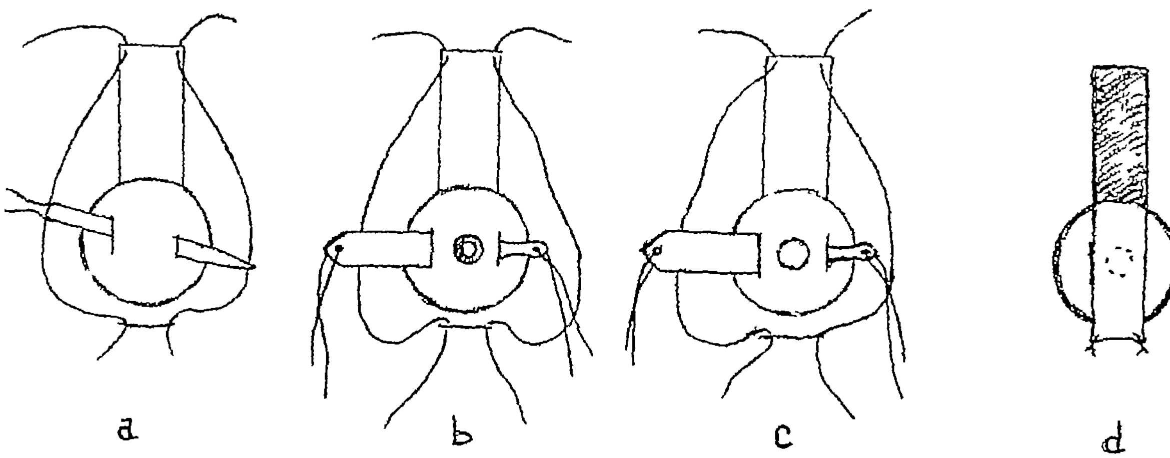

FIG 92 Filatov's keratoplasty *a*, conjunctival flap outlined, and sutures passed Leucoma incised *b*, ivory plate passed between cornea and iris, and corneal disk removed *c*, corneal transplant in place over trephine opening *d*, spatula removed Corneal graft covered with conjunctival flap

and through these he passes the plate between the cornea in front and the iris and lens behind On this support he trephines the cornea in the usual manner (fig 92) Castroviejo (50) cuts the graft with a specially constructed double-bladed knife with adjustable blades and a specially bent keratome, in the belief that with these instruments the graft can be cut more evenly and cleanly than with trephine and scissors

To immobilize the graft, various kinds of sutures and conjunctival flaps are employed Elschnig (101) passes one needle of a double-armed suture of black silk through the conjunctiva at a point about 1 5 mm from the limbus and the other at a distance of 1 to 2 mm from it (fig 93-A) The needles are then made to take a bite of the conjunctiva at similar points below the cornea, so that when the ends are put on tension the two strands will lie parallel to each other over the transplant Thomas (341) retains the graft by cross-stitching through the opaque cornea adjoining the graft, the sutures passing over the surface of the latter in the form of a Maltese cross, and the knots being so placed that they do not lie on the graft or near its margins (fig 93-B)

While fixation by sutures permits of early inspection, it has the objectionable feature of bringing a foreign body into contact with the graft To overcome this objection,

the use of various forms of conjunctival flaps has been suggested. These flaps not only serve to fix the graft in place but have the additional advantage of protecting the corneal epithelium from damage and possibly also assist in nourishing the graft. They have the disadvantage however, of concealing the graft and making it impossible to determine whether or not it has been dislodged Castroviejo (50) covers the grafted area with a conjunctival flap obtained by undermining the conjunctiva from below the limbus, and attaches it to the conjunctiva above the transplant (fig 93-D) Filatov (110) holds the graft in place by a ribbon-shaped flap of conjunctiva turned down from above so that the epithelial surface of the flap covers the epithelial surface of the graft A flap of conjunctiva 5 mm broad and 10 mm. long, with its pedicle at the limbus, is dissected from above the cornea. A suture is passed through each upper angle of the flap and through corresponding points in the conjunctiva below the cornea These

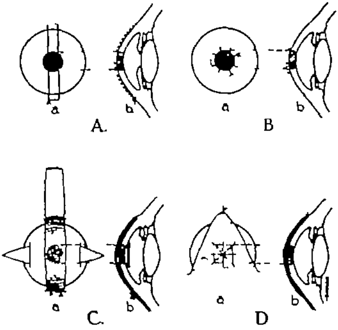

FIG 93 Various methods for immobilization of corneal grafts. *A* two strands of double-armed suture of black silk lying parallel across graft (Elschnig) *B* threads cross-stitched above cornea in form of Maltese cross (Thomas) *C* ribbon-shaped conjunctival flap turned down from above, to cover graft (Filatov) *D*, conjunctival flap reflected from below and attached to conjunctiva above (Castroviejo) (Castroviejo Surg Gynec. & Obst., 1937)

sutures are held aside and not completed until the graft is in place (*fig* 93-C) *If* for some reason, a conjunctival flap cannot be used, Filatov places a sheet of egg membrane, inner surface down, over the graft and fixes both the graft and the membrane by a suture after the manner of Elschnig Rycroft (301) obtains immobilization by drawing a conjunctival flap tent fashion over the entire graft. The conjunctiva is incised around the limbus and is undermined to the equator with blunt pointed scissors. A pursestring suture of #1 silk is passed 1.5 mm from the cut edge, it is inserted in such a way as to render the aperture eccentric, so that when the suture is tightened it will not come in contact with the graft.

Irrespective of the method used to fix the graft, provision must be made for fixation at the time the recipient area is prepared so that there will be no delay in immobilizing the graft after it is in place

Operative Technic The special instruments for corneal grafting include a Hippel

trephine or Castroviejo's double-bladed knife, keratomes, dull-pointed scissors with beveled blades, corneal needles, and fine arterial silk sutures (fig 91)

A rigid preliminary aseptic routine is essential A week prior to operation the eye is irrigated at 2-hourly intervals with 1:5000 oxycyanid of mercury On the evening before operation the eye is washed with a 20 per cent solution of argyrol and the eyelashes are clipped Two to three hours before operation a sedative is administered (p 398) At the time of operation the donor and the recipient are placed on adjoining tables When practicable, the recipient should be operated upon in his bed to prevent postoperative disturbance Two surgical teams operate simultaneously, while one prepares the bed for the reception of the graft, the other enucleates the donor eye Local *anesthesia* is preferable to general in that it eliminates postoperative unrest Castroviejo (50) anesthetizes the cornea and conjunctiva by instilling into the conjunctival sac a 4 per cent solution of cocain and adrenalin 1:1000 The facial nerve is then blocked by injecting 2 cc of a 2 per cent procain adrenalin solution at the site where the nerve crosses the condyle of the mandible, in addition, 1 cc of the solution is injected into the retrobulbar region and a few drops are injected above and below the bulbar conjunctiva

Preparation of Bed to Receive Graft The face is aseptically prepared and draped in the customary manner, and the eye is douched with a 20 per cent solution of argyrol If the graft is to be a large one, the pupil is contracted by instilling into the conjunctival sac a few drops of eserin, and, if small, it is dilated with atropin in order to prevent its subsequent adhesion to the iris The lids are separated by two tractor sutures and are attached to the drapes above and below. The eyeball is immobilized by a bridle suture passed through the superior rectus and another, if necessary, through the medial and lateral recti The precise site for the graft is marked out with the point of a needle dipped in methylene blue The sutures for holding the graft are placed and held aside, or, if a conjunctival flap is to be used, it is outlined and separated at this time A Hippel trephine is then placed over the previously marked-out site and is rotated until about half the corneal thickness is cut through Then, to bevel the graft, the axis of the instrument is made to assume an angle of 45°, and the trephining is continued until about one-third of the circumference of the circle is cut through, the wall sloping from without in · Through this opening a specially constructed keratome or a pair of blunt scissors with beveled blades is introduced, and with this instrument the remaining margins of the circle are cut in a shelving manner so that the outer surface of the bed is larger than the inner

Removal of Transplant While the bed is being prepared to receive the graft, the eye of the donor is enucleated under general anesthesia in the customary manner Briefly, after the necessary aseptic preparation and draping, the lids are separated with a speculum The conjunctiva is seized with a forceps, divided around the cornea, and dissected backward to open the space of Tenon With a strabismus hook the external rectus muscle is brought out and divided close to its insertion The remaining recti muscles are treated in a similar manner With the eyeball dislocated forward, a pair of blunt scissors, slightly curved to conform to the contour of the globe, is passed from the inner side of the eye behind the eyeball, and the optic nerve is severed The remaining oblique muscles and any other strands of tissue still attached to the globe are sectioned Hemorrhage is controlled by pressure Throughout the process of

enucleation care should be taken to prevent injury and drying out of the corneal epithelium

The enucleated donor eye is washed with brilliant green 1 2000, wrapped in gauze, and turned over to the surgeon, who holds it between his thumb and forefinger or places it in a special stand devised by Thomas (341) Majewski (228) obtains the necessary support by emptying the eye and pressing the sclera against the posterior surface of the cornea. With the trephine used in the preparation of the bed, a graft is cut from the cornea, lifted out by means of a spatula passed beneath it, and placed on a pad of sterile gauze previously singed over a flame to free it from lint Thomas transfers the graft to an oil medium Others place it in a watch crystal containing warm normal salt solution or blood serum

Transfer and Fixation of Graft As soon as possible after its removal, the graft is transferred to its bed on a spatula, an iris repositor or a camel's hair brush, care being taken that the corneal epithelium is uppermost. It is fixed in place bv means of the sutures or the conjunctival flap previously prepared The tractor sutures on the lids are removed and one drop of a 1 per cent solution of atropin is instilled into the eye to dilate the pupil and thereby clear the iris from the graft. Finally, a moist sterile dressing is placed over the operated eye, and a bandage incorporating both eyes is applied.

Castroviejo (50) operates in the following manner "The pupil is widely dilated with atropine, and a conjunctival flap is made below (fig 94A) The leucomatous area of cornea to be removed is outlined with a double knife, without penetrating into the anterior chamber (figs 94B–D) A continuous corneal suture is inserted outside the edges of the outlined square (fig 94E) This suture will be destined to hold the transplant in position Another suture is inserted within the outlined leucoma to facilitate the removal of this segment (fig 94F) The upper edge of the leucoma is cut through with a keratome kept at an angle of about 45° in order to obtain shelving of the edge (figs. 94G–H) The other three edges are also cut in a shelving manner with the aid of special scissors (fig 94I) During this last manipulation a gentle pull is exerted on the suture to keep the leucoma away from the lens, which procedure prevents injury to this structure A transplant equal in size and shape to the removed leucoma is obtained in a similar manner (fig 94O) from the enucleated eye of a patient or from the eye of a still-born infant, enucleated shortly after delivery and kept from one to forty-eight hours in Ringer's solution at a temperature of from 2 to 3 C above zero The clear transplant replaces the dissected leucoma (fig 94J–K), and the continuous corneal suture is gently made taut (fig 94L) The conjunctival flap is fastened to the episclera near the limbus with a suture (figs 94M–N) The conjunctival flap retracts by itself in a few days to its normal position. The corneal suture is removed from seven to nine days after the operation.'

After Treatment. Postoperatively, the patient should be cared for by a special nurse and kept absolutely quiet to prevent dislodgment of the graft. The first dressing is done on the third day merely for the purpose of inspection. In the absence of complications, secretions are gently swabbed away, a drop of atropin is instilled in the grafted eye and the bandage is reapplied. The dressing is repeated on the sixth day and again on the eighth day If a conjunctival flap has been employed to fix the graft and the sutures have not cut through spontaneously, they are removed at this

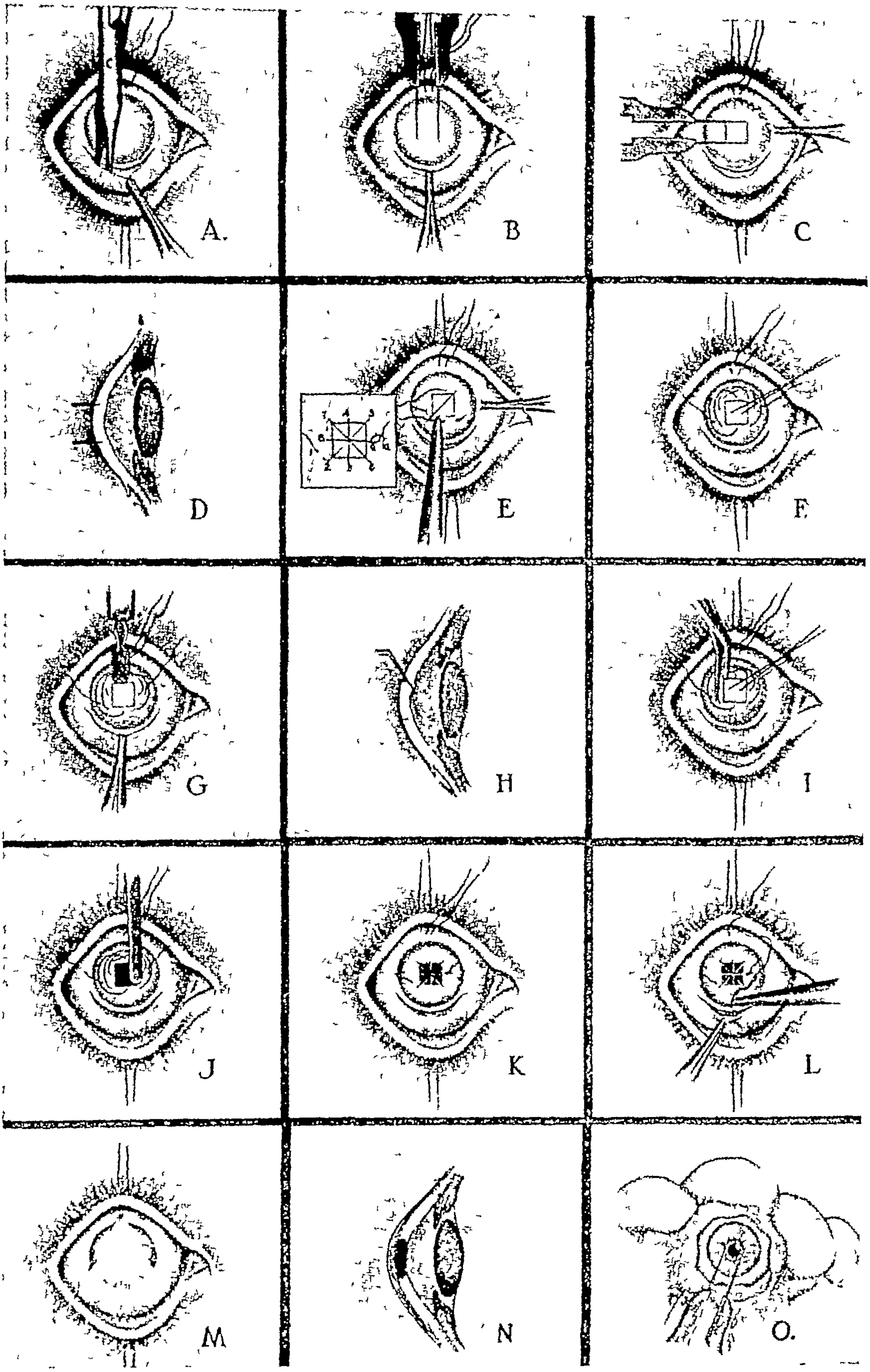

Fig 94

time At the end of a week the unaffected eye is left free, and at the end of three weeks all bandages are discarded

Complications The complications which are apt to follow corneal grafting are dislodgment of the graft, synechia, sepsis, and opacities, of which there are three varieties. The first opacity appears during the first week, clears up toward the end of the second week, and is assumed to be due to the imbibition of liquid. The second appears during the second week and clears up in a week or ten days, it is attributed to the spread of superficial vessels. The third comes on later due to a failure of nutrition and remains as a permanent opacity

Bone Grafts

The foundation for bone transplantation was laid by Ollier (257) in 1867 Since then its therapeutic value has been amply demonstrated, and today it is an established surgical procedure Its scope, however, would be considerably broadened if various basic problems concerning the process of osseous regeneration were solved Among the many matters still in doubt are the ultimate fate of the transplant and the question of which if any, of its various components plays the major rôle in osteogenesis Obviously the solution to these problems would be of the greatest clinical assistance in the selection of the most appropriate type of graft.

The destiny of the transplant opens a debate which began with Duhamel (93) in 1757 and today still remains a subject of conflicting opinions

There are those who maintain that the entire graft survives, becomes revascularized, and grows as an integral part of the surrounding bone. Ollier (257) (1859), as a result of his experiments at Lyons, was the first to accept this view, and it was later shared by Brooks (37), Haas (144), Axhausen (10), Lexer (207), Albee (5), Phemister (278), MacWilliams (223) and others. The proponents of this concept reasonably maintain that the success or failure of a bone graft depends upon the rapidity with which the graft is able to establish an adequate blood supply They point out that small bone grafts will "take" even without periosteum because of their easy access to vascularization whereas large grafts may, without periosteal assistance, undergo necrosis before a blood supply can be established.

Another school of thought, challenging the conclusions of Ollier was originated by Barth (16) (1894) and Marchand (1895), who held that the bone graft becomes necrotic in all its parts and subsequently undergoes regeneration through osteoblastic infiltration from the neighboring bone, the graft itself serving merely in an osteoconductive capacity This concept gained general acceptance, and for about ten years thereafter surgeons turned from the use of autogenous living bone grafts to the implantation of heterogenous bone

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FIG 94 Castroviejo s circumscribed penetrating keratoplasty *A* conjunctival flap raised. *B–D*, leucomatous cornea outlined with double knife. *E* continuous corneal suture placed around outlined square, to immobilize graft. *F* suture passed within leucoma to facilitate its removal. *G–H* upper edge of leucoma incised with keratome at angle of 45 degrees *I*, other three edges of leucoma cut obliquely with special scissors *J–K* leucoma removed and replaced with graft. *L*, continuous corneal suture tightened gently over graft. *M–N* conjunctival flap from below laid over graft and sutured to episclera near limbus *O* graft removed from enucleated donor eye. For details, see text. (Surg. Gynec. & Obst. 1937)

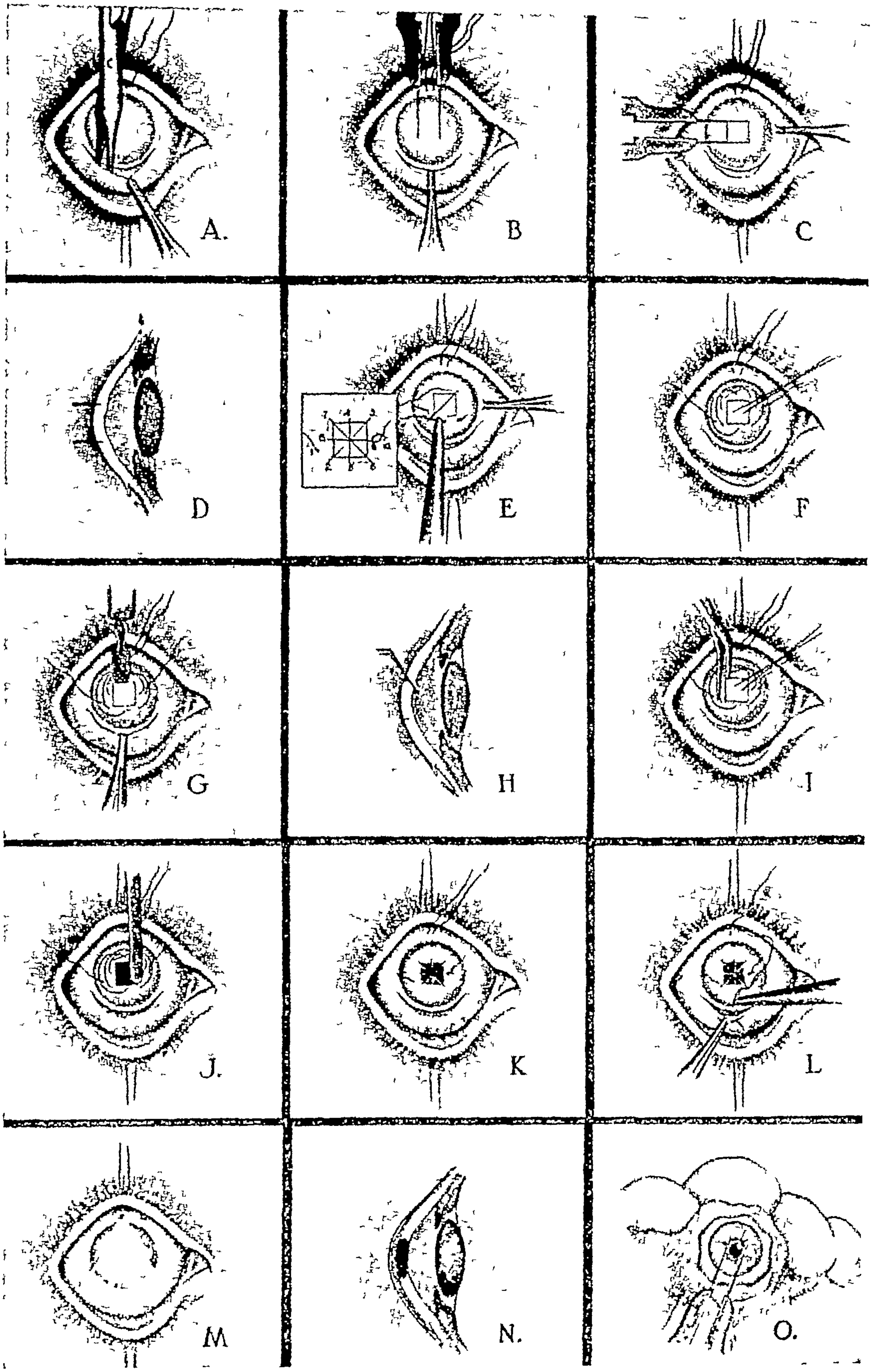

Fig 94

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Still others (116) take an intermediate stand and believe that part of the transplant is absorbed and that part survives and generates new bone According to Trethowan (342), when bone is transplanted under favorable conditions, the osteoblasts on its surface live and proliferate, while those in its deeper parts die The living cells on the surface of the graft, assisted by osteoblasts from the neighboring bone, absorb the graft and at the same time lay down new bone ("creeping substitution") Into the osteoporotic tissue new vessels and osteoblasts enter, and absorption and re-formation take place in the depth of the graft

While the presence of osteogenetic properties in the bone graft is acknowledged by most physiologists, they are still faced with the unanswered question as to which of the component parts of the bone is responsible for osteogenesis At present there are three schools of thought (1) Those who regard the periosteum and endosteum as definite bone-forming organs, believing that osteoblasts arise from the cells of the periosteum and to a lesser degree from those of the endosteum. That the cells of the periosteum and endosteum are the principal source of bone regeneration, the bone cells themselves playing little or no part, was first suggested by Goodwin (1800), and this opinion has since been shared by Syme, Ollier, Axhausen, Lexer, Haas, Phemister, and others Axhausen (10) and Lexer (208) believe that the bone itself dies but that the periosteum and endosteum remain viable and assist in the regeneration of the transplant after the circulation is re-established Phemister (280, 281, 279) is of the opinion that the osteogenic properties reside in the inner layer of the periosteum, the endosteum, and to some extent in the bone cells and fibrous contents of the haversian canals Macewen (220) was the first to take issue with the conclusion that the periosteum possessed bone-forming properties, claiming that it served as a limiting membrane only and as a convenient source of blood supply This view was later accepted by Gallie and Robertson, Cohn and Mann, Ghormley and Stuck, and others Much of the controversy hinges on the question as to what actually constitutes the periosteum, and in this respect Horsley (169) states· "If the cambium layer on the cortex of the bone is included with the periosteum, it is undoubtedly true that this layer contains osteoblasts and will reproduce bone, but if this layer is not considered as a part of the periosteum proper, the periosteum then is only a limiting membrane" (2) A second school believe in osteal regeneration—i e, that bone is re-formed from the bone cells liberated from the lacunae (3) In recent years a new concept of osteogenesis has been suggested, founded on a biochemic, rather than on an anatomic, basis The protagonists of this school assume that definite bone-producing cells do not exist, that bone regeneration is the result of an extracellular metaplasia of connective tissue cells striving toward a functional adaptation (203, 249, 22, 277) Two of the most enthusiastic advocates of this theory are Leriche and Policarde (204), who state. "The formation of bone is the result of a metaplastic change in the connective fundamental substance This metaplasia takes place in 3 ways (1) Transformation of the connective tissue by an edematous infiltration with a multiplication of connective fibrils (2) Infiltration by a special substance chemically undefined, the preosseous substance (3) Deposits in that substance of a calcareous mixture of calcium phosphate and calcium carbonate Osseous metaplasia can occur in all types of connective tissue, embryonal type, fibrous type, etc"

Indications for Bone Grafting

Bone grafts find their greatest application in (1) the restoration of the continuity of a bone following loss of substance from injury disease, or the removal of tumors, wherein the deficiency is so great that direct approximation of the fragments is either impossible or would cause an undesirable shortening and interfere with normal function, (2) the repair of ununited fractures by their capacity to act as osteoconductive tracts (3) uniting the articular ends of bone for the purpose of securing an extra articular arthrodesis a common example of their adaptability in the latter instance being observed in Hibbs' operation in which the spinous processes of several adjoining vertebrae are split and a bone graft fixed between them for the purpose of obtaining ankylosis and thus keeping the part at rest, and finally (4) the replacement of bony contour, for example, in cranial and malar losses. For the latter purpose, however, bone grafts have been largely supplanted by cartilage grafts (p 182)

Autoplastic Transplants

The most convenient sources of bone grafting material are the tibia, ilium, rib, scapula, and fibula the choice depending upon the size and shape of the defect and upon the function of the part to be replaced Generally speaking, the graft should be selected with a view to its vascularity The more spongy the bone, the better its blood supply and the greater the rapidity of osteogenesis. Whenever practicable, the graft should be secured from a bone which subserves a similar function to that of the part lost For example, if an active bone accustomed to motion and strain is to be repaired, the graft is best taken from the tibia. Contrariwise, for the replacement of bones whose function is passive, such as those of the skull and face, grafts from the ribs or from some other comparatively inactive bone are preferable If the transplant is to serve as a pillar for bridging a bone defect or as an internal splint, it must be secured from an area capable of providing a solid block of bone, the most convenient source being the tibia. If the indication is merely to fill a defect, a less resistant bone may be used, such as the crest of the ilium. Where a curve is to be reconstructed and mechanical stability is not an essential feature, an osteoperiosteal transplant from the tibia, consisting of periosteum lined with a thin layer of bone, may be employed (fig 98f-g)

Tibial Grafts. The tibia is a convenient source for grafts, as it is readily accessible and provides grafts sufficiently stable for internal fixation and of a size capable of filling comparatively large defects. If necessary, a graft up to 25 cm long 2 cm wide, and 1.5 cm thick may be cut from this region. But these grafts are bulky and inelastic, their density resists the penetration of new blood vessels, and their removal has a tendency to weaken the leg.

Tibial grafts are best obtained from the flat anteromedial surface of the bone as follows The patient is placed on the table, the leg exsanguinated, and a tourniquet applied. After the leg has been aseptically prepared and draped, a longitudinal incision 20 cm long is made over the tibia (fig 96) The incision is arched, so that when the soft tissues are sutured back into place the suture line will not lie directly over the area from which the graft was removed. The tissues are elevated in the plane

just above the periosteum, and the flap thus formed, consisting of skin and subcutaneous tissue, is turned back to expose the bone Hemorrhage is controlled, and a bone graft of the appropriate size is marked out by an incision through the periosteum To prevent splintering, the graft is first outlined by multiple drill holes and undercut between these holes with a chisel (fig 96b), first on one side and then on the other, in an oblique

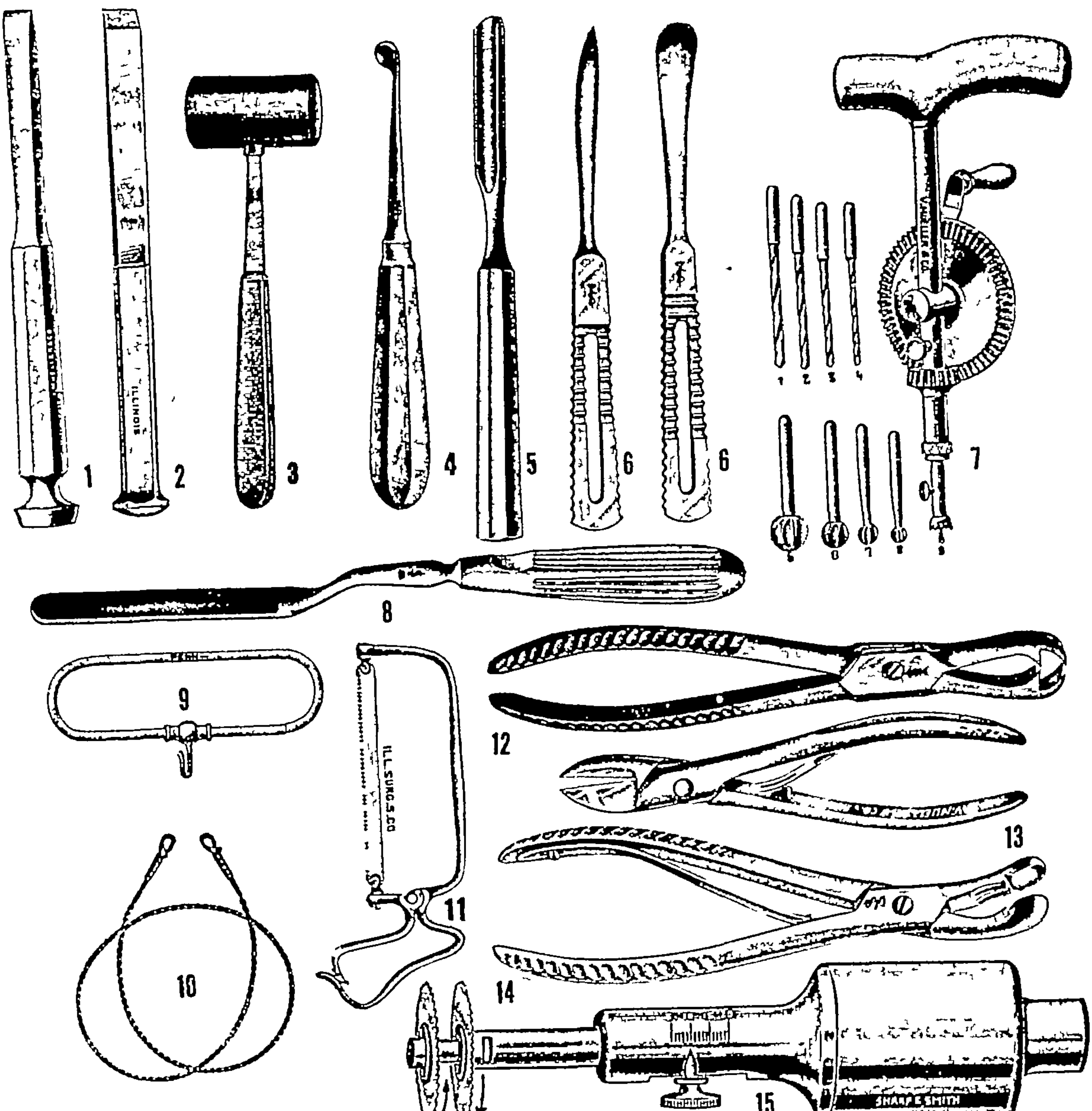


FIG 95 Instruments for bone grafting *1*, osteotome *2*, chisel *3*, mallet *4*, curet *5*, bone gouge *6*, periosteal elevators *7*, bone drill (Stille) with 1 small trephine, 4 burrs, and 4 drills *8*, bone file *9*, Gigli saw handle *10*, Gigli saw *11*, bone saw (Charriere) *12*, bone-holding forceps *13*, bone-cutting forceps (Liston) *14*, rongeur *15*, double counter-rotary saw (Magnuson)

manner so that the cuts will meet beneath the center of the graft No attempt should be made to elevate the graft until it lies free in its bed In the case of patients whose leg muscles are poorly developed and can be retracted to expose a greater surface of bone, the chisel may be substituted by a hand saw or a motor-driven twin saw (fig 96a). The latter instrument will cut through the bone in a very few minutes With

the twin saws adjusted at the proper distance from each other, the bone cuts are made to the marrow cavity, the saws being kept cool by a constant flow of saline solution. The parallel incisions are joined at their extremities by an osteotome or chisel, and the quadrilateral-shaped graft is lifted out. Care should be exercised in cutting the graft not to encroach upon the tibial crest, as the density of the bone in this location renders it undesirable for grafting purposes, and its removal has a tendency to weaken the leg. *Henderson* (156) advises that the spongy bone contiguous to the graft be removed and kept in a warm moist saline pack, to be used later for the filling of any spaces between the graft and its host.

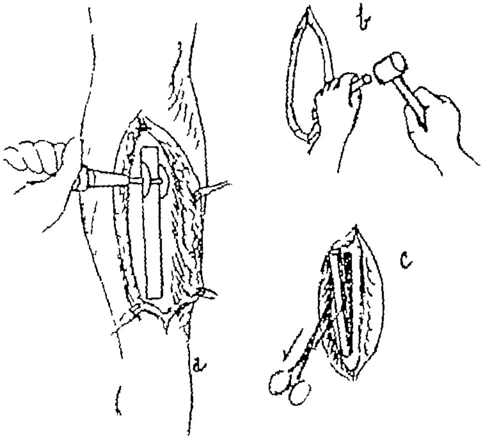


FIG. 96 Removal of bone graft from anteromedial surface of tibia. *a* graft cut with motor-driven twin saw. *b* graft outlined by series of drill holes and undercut with chisel. *c* graft lifted out with forceps.

Iliac Grafts. Grafts procured from the ilium are quickly vascularized because of their spongy character; their removal offers no technical problems, and they can be cut to almost any desired size and shape without residual disability. They are particularly suitable for the replacement of mandibular structures. Unfortunately, they cannot be used in children, because of their cartilaginous character in early life.

A curved incision, convex side down, beginning at the anterior superior spine and extending posteriorly as far as necessary to secure a graft sufficiently large is made over the crest of the ilium down to the periosteum. The soft tissue flap thus outlined is retracted. The gluteus muscle is stripped from the bone until an area of suitable size is exposed. The graft is outlined by an incision through the periosteum and is

resected with a chisel and mallet (fig 97), a metacarpal saw, or an electrically driven motor saw, beginning at the anterior superior spine and working backward The graft may consist of either a part or the full thickness of the ilium, depending upon what is demanded of it In either case it should be cut sufficiently large to permit of overlapping when in place After removal of the graft, the detached muscles are sutured back in place with chromic catgut, the skin is closed, and a small drain is inserted for 24 hours

Rib Grafts Rib grafts are more flexible than tibial grafts and can be bent to assume any desired shape The supply of material is sufficient for most purposes Two or 3 inches of several ribs may be removed without ill effect The instrumentarium is simple, consisting of a scalpel, a periosteal elevator, and a pair of bone shears The chief disadvantage of this graft is its lack of stability which prohibits its use where

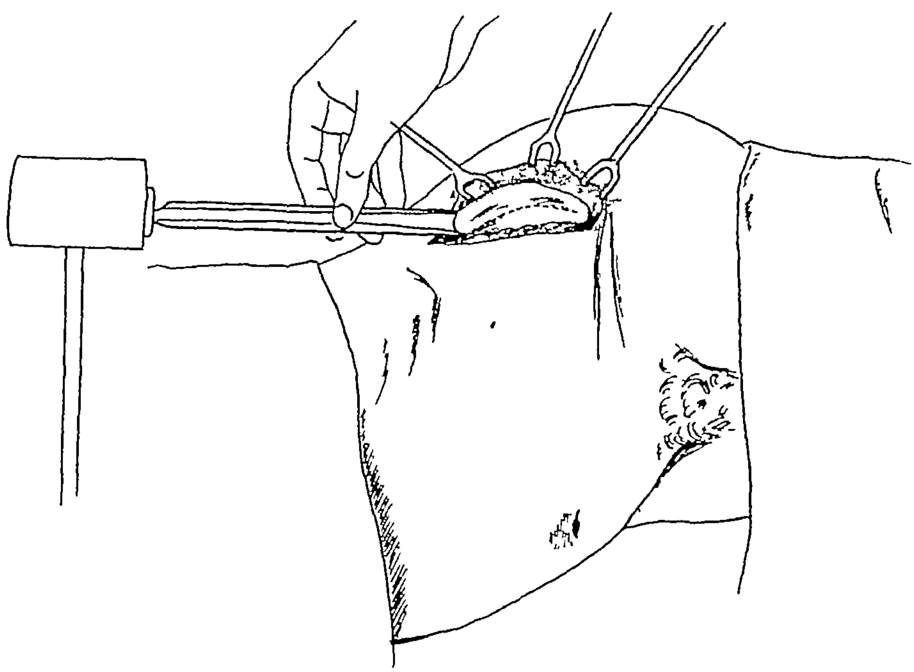


FIG 97 Removal of iliac graft with chisel and mallet For details, see text

strength is required The technic of its removal is essentially the same as that employed in procuring a costal cartilage graft (p 184)

Scapular Grafts The scapular graft can be employed for the repair of small defects only, since the removal of a large section would interfere with the function of the arm To obtain the transplant an incision is made along the vertebral border of the bone at a distance of 2 cm from its margin An area of the required size is exposed by splitting the infraspinatus muscle and fascia and retracting the margins The bone graft is then outlined to pattern and cut through with a chisel and mallet, care being taken to leave the vertebral border intact The plate of bone is now freed by being bluntly separated from the underlying subscapularis muscle After complete hemostasis, the divided infraspinatus muscle is coapted and sutured and the skin wound is closed

Heteroplastic Transplants

All early attempts at bone replacement were necessarily carried out with the use of grafts procured from sources other than the patient himself, since the lack of anesthesia and asepsis would have made the cutting of an autoplastic graft too hazardous a procedure. Von Mackren (1670) repaired a defect in the human skull with a section of dog bone. It is interesting to note that he was forced by the Church to remove the graft, since the implantation into the human body of a bone from a beast was regarded as "marring God's image of man' (221) Similar undertakings were later reported by Macewen, and by Ricard (297) Lane (197) restored the shaft of an ulna by grafting bone from a rabbit Westermann (358) was the first to use boiled bone as a transplant, and this material was later advocated by Martens (233), Bunge (39), and Abrajanov (1) Senn (310) reported success with decalcified bone

While heteroplastic bone grafts have the advantage that they can be obtained in any size, molded to suit the particular need, easily sterilized, and procured without the necessity of mutilating other parts of the body, nevertheless, like all foreign bodies, they are likely sooner or later, as a result of slight trauma, to become absorbed, undergo infection, or be extruded. In view of the present-day success with autoplastic bone grafts, there would seem to be little demand for heteroplastic substances. However, it cannot be denied that some surgeons of wide experience still feel that these materials offer the best solution to the problem of bone grafting

Recently Orell (259) has reported successful results following the use of heterogenous grafts obtained from animals and amputated limbs which he terms "os purum' "os novum,' and "boiled bone' Os purum is bone which has been freed of fat, connective tissue and protein by a physiochemical process but still retains some of its collagenous matrix. Orell claims that by this "cleansing procedure" the bone canals are emptied and made adaptable for the reception of tissue fluids and tissue cells from the host. The advantage of os purum is that it can be kept on hand and sterilized by boiling in physiologic salt solution. It is obtainable in various sizes and can be given the desired shape with the help of hand and motor-driven tools Orell (259) defines os novum as "immature living bone tissue with great proliferative power It is produced by implanting a long, narrow os purum splint of suitable shape subperiosteally over the anteromedial surface of the tibia. When the material is excised from one or two months later, a profuse growth of new, soft, vascular bone is found in the clefts between the periosteum, the os purum, and the tibia This new bone which I have called os novum, is excised with a special bone spatula and then transplanted to the desired place Because of its softness it can easily be shaped to fit into the new bed and is better tolerated by the soft tissues than is fresh mature hard bone, moreover, owing to its great proliferative power it is suitable for conditions in which new bone formation is desired and where fresh material cannot be taken from the skeleton itself, as for example in the case of children. The greatest drawback of this material is its poor supportive power which forbids its use for internal fixation Although these grafts open up fascinating possibilities, Orell himself states that it is impossible as yet to evaluate their merits properly

Varieties of Bone Grafts

Bone grafts are classified according to methods of fixation as follows· (1) the lateral graft, (2) the massive onlay graft (Campbell and Henderson) (44), (3) the inlay graft (Albee), (4) the intramedullary graft, and (5) the osteoperiosteal graft

The *lateral graft* is so cut as to fit accurately into the ends of the fragments which have been properly prepared and "stepped" to receive it It finds its greatest application in cases where there has been an actual loss of bone (fig 98a)

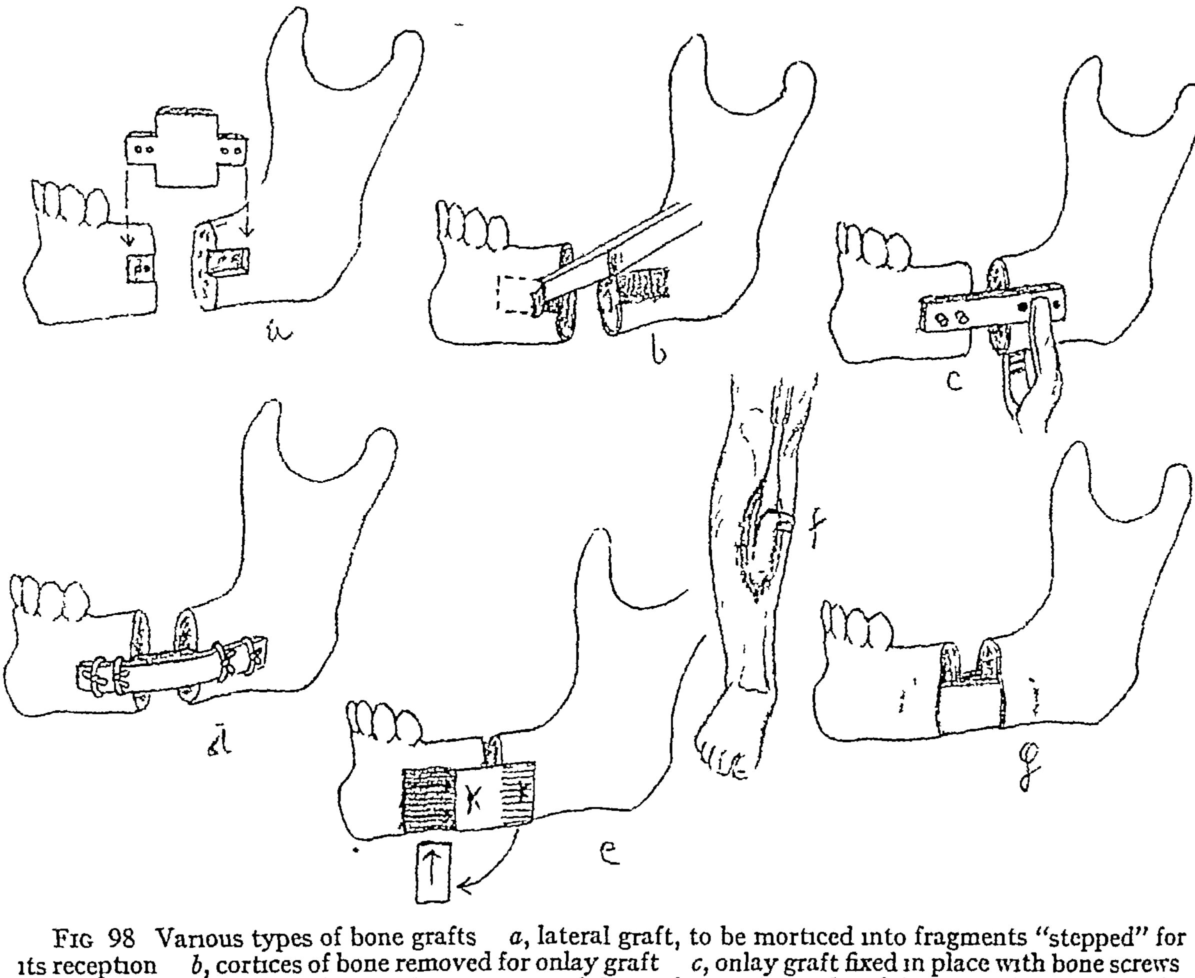


FIG 98 Various types of bone grafts *a*, lateral graft, to be morticed into fragments "stepped" for its reception *b*, cortices of bone removed for onlay graft *c*, onlay graft fixed in place with bone screws *d*, inlay graft secured in place with catgut *e*, sliding inlay graft displaced from one fragment to the other, to bridge defect. *f*, osteoperiosteal graft removed from tibia *g*, osteoperiosteal graft fixed in subperiosteal pockets, medullary surfaces facing each other

The *massive onlay graft* is a large graft applied and firmly fixed to the freshened cortices of the fragments (fig 98b-c) It affords good stability and a large area of contact which is conducive to early union It is particularly suited to the repair of ununited fractures

The *inlay graft* is a transplant so cut as to fit accurately into slots made in the fragments. Frequently these grafts may be wedged into position in such a way that they will become self-retaining (fig 98d). If further fixation is required, it is obtained by sutures passed through drill holes in the margins of the groove and tied securely over the graft. These grafts are especially useful in the repair of ununited fractures of long bones The *sliding inlay graft* is a long narrow graft cut from the

shaft of the affected bone in such a manner that the portion derived from one fragment is double the length of that from the other (fig 98e) When the grafts have been detached from their deep connections, the longer fragment is slid over so as to bridge the line of the defect, and the shorter fragment is used to fill up the space left by the displacement of the longer one. The main advantage of this type of graft is that it obviates the necessity of mutilating other parts of the body and, by requiring only one operative field, it eliminates the danger of cross-contamination.

The *intramedullary graft* is one impacted directly into the medullary cavity of the fragments In some cases it may be applied by impacting it into the medulla at one end and inlaying or outlaying it at the other While this type of graft does not necessitate much exposure of the fragments and eliminates the need of additional fixation, it is rarely used as it destroys the medulla of the bone and endangers the blood supply of the host fragments, provides only fair fixation, and has little if any osteogenetic properties, moreover should the graft fail, as it frequently does, the bone is left more devitalized than before It is occasionally employed, however, in cases where the affected bone is thin and atrophic, under which circumstances it may be easier to implant a graft into the medullary canal than to inlay or onlay one into the sides of the shaft.

The *osteoperiosteal graft* is one consisting of periosteum lined with a thin layer of bone, and is usually obtained from the tibia (79) (fig 98f, g) It finds its greatest usefulness in the replacement of thin lamellae of bone, as in cranioplasty, and in the reconstruction of parts of a given shape—for example, the curve of the mandible The cutting of these grafts is simple, their implantation incurs little difficulty, and they supply all the elements necessary for bone regeneration. The chief objection to their use is that they offer little stability and require a comparatively long time for organization. The graft is obtained in the following manner The tibia is exposed (p 171) and a pattern of the defect is placed on the bone and outlined on the periosteum with a scalpel. With a thin broad chisel held horizontally and with its bevel directed posteriorly, the bone is penetrated to a depth of 1 or 2 mm. and is shaved off together with the overlying periosteum The technic of the application of this graft is outlined on page 1279

Preoperative Considerations

Prior to bone grafting, as in all grafting procedures, the potential healing qualities and the general condition of the patient must be evaluated Because infection is the principal cause of failure, 6 months to a year must be allowed to elapse following the cessation of all inflammatory and infective processes Sinuses must have healed and all redness and swelling disappeared. X ray examination should show the absence of sequestra After osteomyelitis, conditions suitable for grafting may not be present for years. In the case of malignancy a sufficient interval must have elapsed to insure against local recurrence, and this usually requires a delay of a year or two In the case of ununited fractures no definite time for grafting can be set because of the varying underlying causes for the non union, but generally speaking 6 months has been accepted as a sufficiently long period to wait.

Because bone grafts do not take on a new blood supply as readily as do other grafts, it is especially important that an adequate blood supply be provided for the

accurately If such be the case, it is placed on a special side table with elevated edges to prevent accidental slipping during the process of trimming It is manipulated with bone forceps rather than with the fingers, as the spicules of bone may perforate the glove and lead to infection Modeling is done with bone-biting forceps and files of various shapes Muscle fragments, if present, are removed, care being taken not to disturb the periosteum Albee (5) incises the periosteum in numerous places to induce a better blood supply All surfaces which are to be approximated directly with the host bone are beveled to permit of maximum surface contact All medullary fragments are saved for later use in the packing of the space between the graft and the fragments Any small particles of bone which collect on the graft during the modeling process are allowed to remain or are lifted off with a forceps They should never be wiped off with gauze or cotton sponges, as small fibrils from the latter material will adhere and act as foreign bodies, and may possibly lead to suppuration If external fixation of the graft is necessary, holes are drilled for the reception of ligatures at points corresponding to those made in the recipient bone

Application of Graft. When the graft has been properly prepared, the wound is reopened, the gauze pack removed, and the graft, held firmly in a bone forceps, is placed into the defect in such a manner that similar elements of the graft and host bone come in contact—that is, periosteum to periosteum, cortex to cortex, and marrow to marrow Such positioning calls for the least possible rearrangement of the callus trabeculae and a minimum of vascular readjustment

Fixation is best accomplished by a dovetailing or impacting of the transplant into the bony defect, so that the parts are locked into a solid unit Kirk (187) describes a type of self-retaining graft as follows. "An inlay bed was cut with the Albee saw The cortical bone at each end of the gutter was then beveled from above downward with a small osteotome The graft was cut slightly longer than the gutter, and its two ends were beveled from above downward The graft was placed in the gutter with one end fixed under the beveled cortex, the other end was then jimmied down into the gutter With a bone set and mallet, the graft was slid toward the end last introduced The graft then became locked into position " It is frequently possible to secure fixation by inserting the ends of the graft into periosteal pockets formed by separation of the periosteum, together with the overlying soft tissue, from the bone ends (fig 98g)

Should additional fixation be necessary, it may be obtained by passing sutures of kangaroo tendon, chromic catgut, or wire through corresponding drill holes in the fragments and in the graft If wires are preferred, they are twisted to hold the graft in firm contact with the fragment, the ends are cut off short and are turned to lie parallel with the bone surfaces, in order to prevent irritation of the soft tissues Fixation may also be secured by means of autogenous or beef bone pegs made with a motor-driven doweling instrument of the same diameter as the drill employed to make the holes While there is a decided objection to the use of foreign bodies in the form of metal plates, bands, screws, etc, on the grounds that they impair the viability of the graft by their irritating effect, act as potential foci of infection, and are frequently extruded, there are occasions when they must be resorted to if prolonged exposure of the tissues is to be avoided

Henderson (156) uses the following technic in applying an onlay graft (fig 99):

"The flattened medullary side of the bone graft is placed against the prepared areas on the cortices and held firmly in this position with bone holders. A drill is then put through the bone graft, through the proximal cortex, across the medullary cavity and through the opposite cortex. Then a tap of the same size is put in to steady the bone graft, and this process is repeated so that the four taps are left protruding in each fragment. This steadies the fragments and the bone graft, and the surgeon can then tell whether the position is satisfactory If it is, one tap is removed and a beef bone screw of corresponding size is inserted. This is repeated for each drill hole, securely holding the fragments in position. The large tops of the screws are bitten

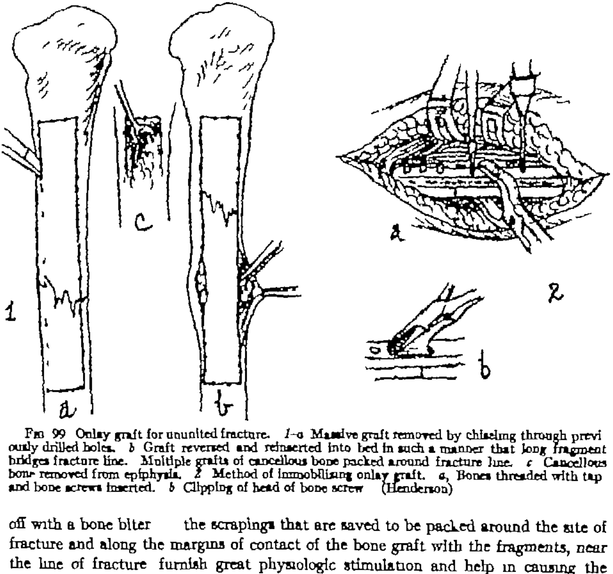


FIG 99 Onlay graft for ununited fracture. *1*–*a* Massive graft removed by chiseling through previously drilled holes. *b* Graft reversed and reinserted into bed in such a manner that long fragment bridges fracture line. Multiple grafts of cancellous bone packed around fracture line. *c* Cancellous bone removed from epiphysis. *2* Method of immobilizing onlay graft. *a*, Bones threaded with tap and bone screws inserted. *b* Clipping of head of bone screw (Henderson)

off with a bone biter the scrapings that are saved to be packed around the site of fracture and along the margins of contact of the bone graft with the fragments, near the line of fracture furnish great physiologic stimulation and help in causing the fragments and graft to unite rapidly This insures a large amount of spongy bone near the fractured ends, which are sluggish physiologically and need this stimulation.

Closure of Wound. When the graft has been anchored in place, the subcutaneous structures are united snugly around the bone with sutures of #1 chromic catgut. Drainage is omitted The skin is closed with on-end mattress-sutures of silk, and the part is immobilized either by means of splints or a plaster cast.

After-Treatment. The after treatment is as important as the operation itself

Immobilization must be secured until the graft becomes established in its new location. This is especially important in the first few weeks since during this period absorption gains headway over generation of new bone, and minor influences may cause the graft to fracture. Immobilization is maintained until Roentgen examination shows solid fusion of the graft with the host This usually requires from 10 to 16 weeks, depending upon the size of the graft When the cast is removed, physical therapy in the form of diathermy and massage is instituted to overcome stiffness Inasmuch as the graft does not attain its full strength until its trabeculae have been rearranged to conform with those of the fragments, splints and braces are employed for a while to relieve the strain

Cartilage Grafts

Cartilage is an unrivaled grafting material especially suited to replace bony losses about the head and to add prominence to external surfaces. It was first employed by Koenig (190) to repair a loss of the larynx and trachea Subsequently von Mangoldt (229) (1889) used costal cartilage to furnish a nasal skeleton, and Nélaton and Ombrédanne (253) (1904) buried grafts of this material under the forehead skin for the same purpose It has since found wide application in the building up of saddle-noses (p 697), the reconstruction of orbital ridge losses and sunken sockets, and the repair of skull defects

Because cartilage is lymph-nourished, it "takes" readily, retains its original morphology, and does not become absorbed or tend to shrink or disintegrate, even in the absence of perichondrium While it is true that calcification and partial replacement by dense fibrous tissue may take place, nevertheless, these changes do not alter the architecture of the graft The material is easily obtained in any amount and can be shaped without difficulty to conform to any desired pattern It is well tolerated by the tissues Loeb (211) found that the emplacement of autografts of cartilage in the tissues occasioned but little cellular reaction Its chief drawback, when used as a graft, is its failure to form an organic union with bone, to which it becomes connected only through fibrous tissue

Source

For the repair of small defects, such as those of the ear, eyelid, and ala of the nose, cartilage grafts may be obtained from the auricle or from the nasal septum In the case of defects requiring more material, costal cartilage must be resorted to For most purposes the broad plaque formed by the fusion of the cartilages of the seventh, eighth, and ninth ribs is chosen, as it is easily accessible and provides a large amount of material When long straight sections are needed, the cartilage of the individual ribs serves well The curve of the cartilage may also be utilized to advantage in cases requiring the reconstruction of a natural curve. While the majority of surgeons prefer autogenous cartilage, some have found that homogenous transplants compare favorably with fresh autogenous material (252, 132, 330, 319).

Recently, the use of cadaver cartilage preserved in alcohol has been revived. Peer (271) implanted sections of human and septal costal cartilage preserved in 50 per cent alcohol beneath the chest skin of other human beings and removed them at intervals

of 7 days to 14 months. A reaction of the foreign-body type was seen in the host tissues about the transplant, lasting until the thirty second day, but largely absent in the sections removed later From the thirty-second day up to and including the fourth month, the grafts remained as tolerated dead foreign bodies. In the older sections fibroblasts from the host grew into the cartilage graft. There was definite absorption of the cartilage and, in one area, calcification.

O'Connor and *Pierce* advocate the use of what they call refrigerated cartilage isografts. The cartilage is obtained from a rib stripped of its perichondrium, washed in tap water, placed in a sterile glass container, and covered with a solution of 1 part aqueous merthiolate (1 1000) to 4 parts of sterile normal saline. The container is placed in a refrigerator and is taken out only when the solution has to be changed, cultured, or used for grafting purposes. O'Connor and Pierce conclude "1 Cartilage isografts can be sterilized, preserved, and refrigerated in merthiosaline for an indefinite period of time. The length of time of preservation does not materially affect the cartilage as a graft. 2 Infected refrigerated cartilage isografts can be re sterilized and preserved for use at a later time 3 Merthiolate (1 1000) 1 part and sterile normal saline 4 parts when refrigerated act as an efficient antiseptic and preservative for cartilage isografts 4 Refrigerated cartilage isografts are efficient and economical for the patient requiring reconstruction surgery They eliminate the necessity of rib cartilage resection, give one a storehouse of easily available material that can be interchanged regardless of age, sex, color, race, or blood grouping 5 Refrigerated cartilage isografts at times cause slightly more of a local reaction but this is a helpful sequela. They bend or curl with much less frequency than do autogenous cartilage grafts. 6 Refrigerated cartilage isografts are, for certain types of contour reconstruction, our material of choice as they are easy to obtain, will keep in vitro indefinitely, will not absorb, will resist infection, are pliable, are easily sterilized, and will lend themselves favorably to sculpturing"

The cartilage graft may be transferred directly into the defect or it may be implanted under the skin and later raised simultaneously with the soft tissue in the form of a flap Whether or not the perichondrium should be preserved will depend upon the purpose of the graft. In any case, contrary to the theory of Fischer (112), it plays no part in the question of failure or success of the "take" Under most circumstances it is advisable to remove it, as its absence facilitates the shaping of the graft. There are cases, however, in which it is retained to advantage. For instance, where it is necessary to attach the graft to its bed, the perichondrium may serve as a point of anchorage for the sutures, where angulation of the graft is required, as in the repair of the nasal framework, the perichondrium may be employed to form a hinge, and where a curve in the supporting structure is desired, retention of the perichondrium on one side of the graft will cause the cartilage to curve to the perichondrial side.

Preparation of Recipient Bed

Before undertaking the implantation of a cartilage graft, the parts destined to immediately surround it must be given careful consideration. If the overlying soft tissues are poorly nourished or have been destroyed, the nutrition of the part must first be improved or the tissues replaced. Scars, if present, must be eliminated or made soft and pliable by massage. If the tissues were previously infected, sufficient

time must have elapsed to assure against the possibility of recurrence When feasible, the bed upon which the cartilage is to rest should be of periosteum to promote firm adhesion In the absence of periosteum, provision should be made to brace the graft by the chiseling of niches in the adjacent bone The soft tissue pocket should be large enough to receive the graft comfortably but not so large as to permit of its dislocation.

Removal of Rib Cartilage Graft

The graft is procured from the right rather than the left side of the chest, in order to eliminate the danger of injury to the pericardium The area is prepared and draped in the usual manner (p 89), and a sand bag is placed under the patient's right side to make the rib arch more accessible

Instruments Besides the ordinary instruments used for the incision and closure of soft tissue, the following (fig 100) must be included: periosteal elevator, Doyen's

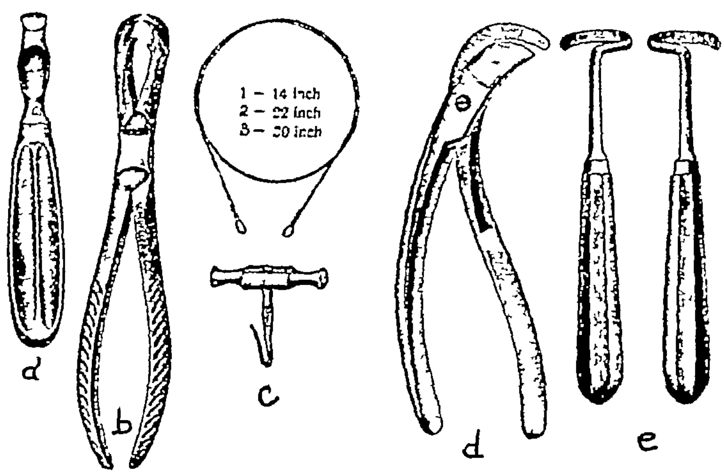


FIG 100 Instruments for removal of cartilage grafts *a*, periosteal elevator, *b*, Ferguson bone-holding forceps (Mueller) *c*, Gigli saw and handle, *d*, rib cartilage shears, *e*, right and left Doyen's raspatory (Jeffrey-Fell)

raspatory, rib-cutting forceps, rongeur forceps, gigli saw, Ferguson's bone-holding forceps, retractors, 20 cc glass syringe with 3-inch needle, ligatures (plain catgut #1, chromic catgut #1), and sutures

Anesthesia The operation may be carried out under general or local anesthesia If a local anesthetic is employed, it is well to supplement it by small amounts of gas-oxygen just before the shears are introduced for the division of the cartilage, for although removal of the cartilage causes the patient no actual pain, the manipulation is apt to be distressing

Local anesthesia is secured in the following manner. Several wheals are raised over the ribs at the ventral and dorsal extremities of the proposed graft Through each of these a 2-inch needle is thrust until its point abuts the surface of the rib It is then pushed obliquely until it reaches the lower border of the rib, where it is turned into the subcostal groove Here 5 cc of a 1 per cent solution of procain epinephrin are injected to block the intercostal nerves The outer surface of the rib is then infiltrated and finally the skin The process is repeated until the entire area to be operated on

is anesthetized (fig 101) The field of infiltration should be sufficiently wide to include the intercostal spaces lying above and below the selected rib or ribs. Ninety to 120 cc. of the solution are usually sufficient to secure the desired anesthesia.

Incision and Removal of Cartilage The cartilage is exposed through a vertical skin incision 10 to 15 cm. long and 5 cm from the midline It is so planned that the middle of the incision lies over the seventh costal cartilage (fig 101) All severed vessels are immediately clamped and ligated, and towels are adjusted to the wound edges with towel clips. The incision is then deepened to the rectus muscle, which is separated in the direction of its fibers to expose the seventh, eighth, and ninth costal cartilages. A piece of cartilage considerably larger than the required graft is outlined with a knife on the perichondrium. The section may comprise the entire thickness

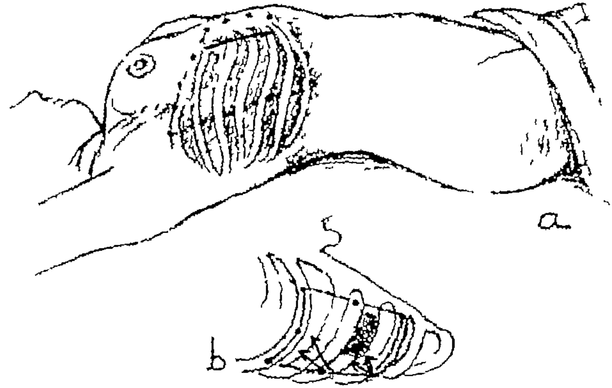


FIG 101. Blocking intercostal nerves for removal of rib cartilage graft. *a* dotted lines indicate *extent of field block.* Solid line shows outline of incision *b* arrows indicate direction of *infiltration.* Shaded area represents portion of cartilage to be removed.

of the costal cartilage or only a part of it, depending upon the size of the desired transplant. In the latter case, the excision is facilitated by the use of a chisel, or a gouge patterned after the wood carver's instrument (figs. 102–103) If the cartilage is to be removed throughout its entire thickness, it is best done subperichondrially, *in order to* prevent injury to the intercostal structures and pleura (*fig* 104) The perichondrium of the rib cartilage from which the graft is to be cut is incised longitudinally Through this incision the membrane is separated above and below to bare the *external* surface of the cartilage It will be found that the more completely the outer surface has been freed, the more easily the inner perichondrium can be stripped. At the outer extremity of the incision the perichondrial dissection is continued around the under surface of the rib for a distance sufficient to allow the introduction of a Doyen's raspatory During the separation of the perichondrium from the inner aspect of the car

tilage, the elevator should be made to hug the cartilage closely to avoid injuring the intercostal arteries and nerves, the internal mammary artery, and the pleura The raspatory is introduced into the space between the cartilage and the perichondrium and worked back and forth until the cartilage is stripped for the desired distance. The membrane will be found to separate with surprising ease. Thus freed, the cartilage is cut through at both ends with a pair of cartilage shears or a bone-cutting forceps A convenient method is to pass a gigli saw around the cleared cartilage, using a silk suture as a pilot After the gigli saw is in place, the handles are attached and the cartilage cut through Care should be taken that the cartilage is entirely freed before its extraction, otherwise, the traction occasioned by its removal will cause unnecessary pain by dragging on unanesthetized structures.

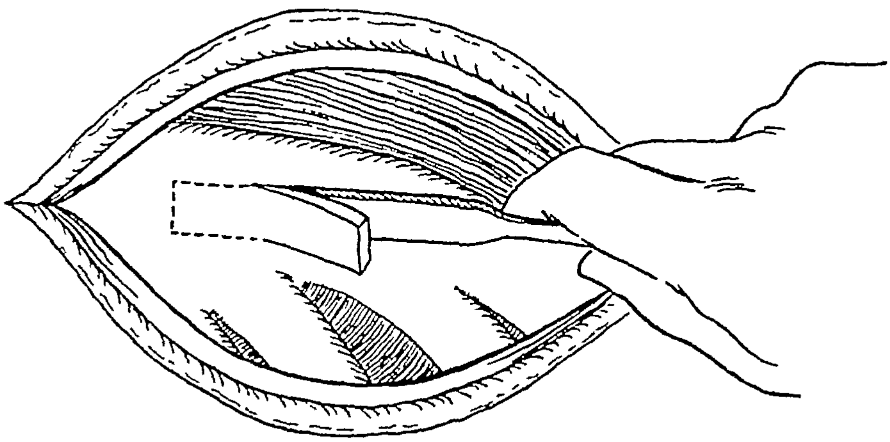
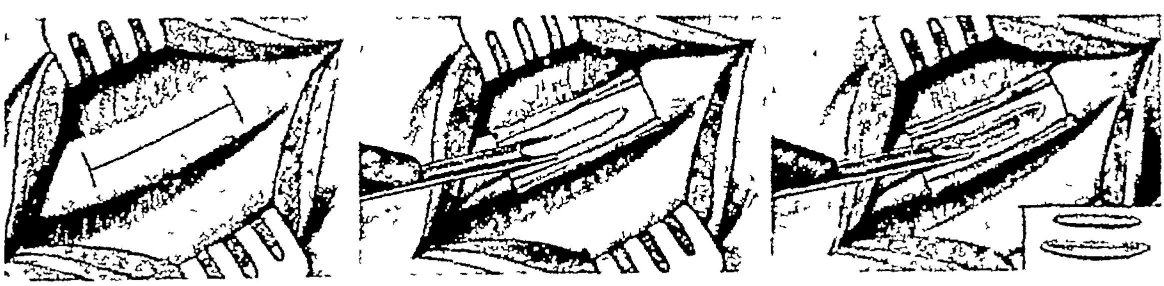


FIG 102 Removal of partial thickness costal cartilage graft with chisel



a b c

FIG 103 Removal of grooved cartilage graft with gouge chisel *a*, incision made in perichondrium. *b*, perichondrium reflected, and cartilage removed with Kelly chisel *c*, grooved cartilage graft removed by carrying instrument to deeper level. (Kelly, Surg Gynec & Obst, Vol 44)

The perichondrium left in the donor area does not seem to influence the skeletal rigidity, as indicated by the findings of Bisgard (23), who carried out a group of experiments on dogs In each of 5 dogs one costal cartilage was resected and the remaining perichondrial tube reconstructed At the termination of the experiment these tubes had become ribbons of normally pliable fibrous tissue with no palpable evidence of skeletal tissue However, a study of numerous histologic sections demonstrated the presence of a few small islands of fibrocartilage within the thick layer of fairly dense fibrous tissue Obviously, chondrogenesis had played an almost negligible part in the reparative process There was also no evidence of invasion of the perichondrial tubes by the proliferating new bone at the sternal and costal ends.

Following the removal of the graft the assistant checks the bleeding, closes the chest wound in layers, inserts a rubber drain, and straps the chest as for a fractured rib. Meanwhile, the surgeon models the graft.

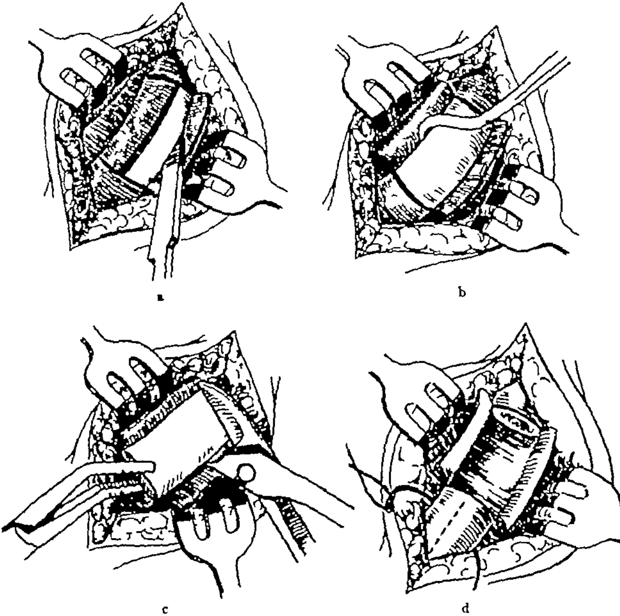


FIG. 104. Subperichondrial removal of rib cartilage graft. *a*, perichondrium incised longitudinally and reflected, to bare external surface of cartilage. At one extremity dissection continued around under surface of rib. *b* Doyen raspatory passed around cartilage and worked back and forth until cartilage is freed for desired distance. *c* freed cartilage cut through at both ends with cartilage shears and removed. *d* In case of inadvertent injury to intercostal vessels, hemorrhage is controlled by ligature passed around rib. (Lexer)

Modeling of Graft. The transplant is placed on a special side table with elevated edges to prevent accidental slipping during the process of trimming. It is picked up with a forceps, and with a sharp knife is shaped to conform to the missing part. The under surface is modeled to fit snugly into the bed which is to receive it, and the sides and top are fashioned to correspond with the desired surface contour. All corners should be rounded to prevent irritation of the soft tissues which will ultimately sur-

round it. It is advisable to shape the transplant in accordance with a previously constructed model of the defect, as in this way the need of repeated insertions with the associated danger of infection is eliminated. Any surplus pieces of cartilage should be stored beneath the skin at some convenient site, such as the right iliac fossa or right submammary fold, to be used as a reserve in case of need.

Before proceeding with the implantation of the cartilage, the operating personnel are supplied with fresh gowns and instruments.

Insertion of Graft. The shaped transplant is grasped with a toothed forceps and inserted into its bed through the initial incision, the margins of which are widely retracted to prevent the graft from becoming contaminated by contact with the skin. If the graft is correctly modeled and its bed properly prepared, it will slip easily into place and immediately obliterate the deformity. If further positioning is necessary, it can easily be accomplished by digital manipulation of the graft externally. Any blanching of the skin over the graft indicates too great tension upon the surrounding soft parts, and under such circumstances the graft must either be removed and made smaller, or the soft tissues must be undercut sufficiently to assure tensionless closure, otherwise, necrosis of the overlying tissues is apt to take place. When the graft is in its proper position, the incision is carefully closed with on-end mattress-sutures of fine silk, and a pressure dressing applied and kept in place for a week. Should the graft become displaced or assume an asymmetrical position, the original incision is opened, the transplant is separated from its fibrous tissue adhesions and, without being removed, is readjusted and immobilized.

Nerve Grafts

The first nerve grafting operation performed on a human being is attributed by Stookey (328) to Albert (1878), and the first histologic study of the degenerative and regenerative changes taking place in nerve transplants is accredited to Huber (171) (1895). Up to the last few years (172) the subject of nerve grafting was a discouraging one and was viewed with skepticism. Stopford (329) reported 20 cases of autogenous nerve grafts in which all failed to restore function. The general attitude of American surgeons was expressed by Babcock (11) who stated that "nerve grafts to bridge defects in peripheral nerves should be considered useless and unnecessary." With the demonstration by Duel and Ballance (92) in 1931, first in monkeys and later in man, that voluntary and emotional control of the facial muscles could be restored by the implantation of nerve grafts into defects of the facial nerve, great interest was aroused among surgeons, and a more optimistic outlook was created. However, considerable difference of opinion still exists as to the value of nerve grafting, inasmuch as the rationale of the underlying principles cannot be entirely correlated with present-day physiology. Nevertheless, a sufficient number of good results have been obtained to warrant the procedure in cases where nerve destruction is so extensive that the proximal and distal ends cannot be brought together by direct approximation despite expedients to bring this about, such as free mobilization of the ends, rerouting over a shorter course, change in posture to shorten the distance, or gradual lengthening by a 2-stage operation.

A knowledge of the histologic changes taking place after the severance of a nerve is of paramount importance to a comprehensive understanding of the problem presented

by nerve grafting When a nerve has been cut, the peripheral segment, separated from its nutrient center, undergoes Wallerian degeneration which is completed in 3 or 4 weeks This process is manifested by atrophy of the axis cylinder, fragmentation of the myelin sheath, and proliferation of the nuclei of the neurilemma. If the continuity between the severed nerve ends is restored, partial or complete regeneration may take place. As to the mechanism, some believe that the axis cylinder of the proximal end elongates or that new axis cylinders form and grow down into the peripheral segment Others (185, 11) hold that regeneration takes place from the distal end of the divided nerve, new axis cylinders developing and spreading upward to unite with those of the central end.

What is said regarding the most appropriate time for operation following nerve injury (p 291) applies equally to nerve grafts. Generally speaking, the longer the *interval between the injury and its repair, the poorer the results*, since the severed nerve ends undergo a progressive fibrosis which makes it more difficult for new axones to penetrate them, and the muscles become atrophied and stretched as a result of disuse. The most favorable prognosis is offered when grafting is done within 2 months after injury It has been estimated that the chances of recovery are reduced by 30 per cent if the operation is delayed until the second year, by an additional 50 per cent if done in the third year, and that after this time no favorable result can be expected.

Whether or not grafting is warranted is determined by the condition of the muscles As long as they are capable of responding to stimulation, the restoration of continuity by the interposition of a graft may bring about a return of function. If, on the other hand, the muscle fails to respond to galvanism and has undergone atrophy and fibrosis, a nerve graft would be useless, since the nerve would have no functioning muscular fibers to innervate. Nerve grafting is more likely to be successful when done on nerves of small caliber inasmuch as the defect can be bridged by an equally small-calibered graft, which is advantageous in that small grafts can obtain nourishment from the surrounding lymph during the period of vascularization, whereas in a larger calibered graft the lymph cannot penetrate its substance as readily and a central necrosis may take place before the blood supply can be re-established. If the defect involves a purely motor or a purely sensory nerve grafting offers more satisfactory results than in the case of a mixed nerve, since there is less likelihood in the former instance that the filaments will grow down the wrong pathway

Source

The graft is procured from any easily accessible nerve that can be spared without too great a disturbance of function. The character of the donor nerve, whether motor or sensory, does not seem to affect the restoration of function in the recipient nerve It must be of such a caliber as to correspond exactly to that of the recipient nerve, if too large or too small, raw areas will remain to undergo fibrosis. For the same reason, the use of many grafts of small caliber grouped cable-fashion is best avoided (fig 106)

Duel and Ballance (92) in their work on facial paralysis found the anterior femoral cutaneous to be the most satisfactory, in that it supplied any required length, could be easily located and its section occasioned only slight anesthesia They first used fresh autografts from the nerve of Bell, because it had the required caliber, was easily

dissected, and furnished any desired length, but the resultant paralysis of the serratus anticus, when the nerve ends could not be reunited, led them to experiment with the intercostals The sixth, seventh, or eighth intercostals were employed because they were easily found, supplied any desired length and the sensory and motor impairment was negligible; but here the danger of injury to the pleura led them to their final choice, the anterior femoral cutaneous

Either fresh or degenerated nerve grafts may be used Duel and Ballance (92) after experimenting with both types came to the conclusion that the latter were superior. Their experiments with these grafts were prompted by the conclusions of Tello (336) that "the empty channels of the degenerated grafts are especially rich in neurotropic substances, whereas in the normal nerve grafted directly, though not entirely absent, they are liberated very tardily," and Ramon y Cajal (285) that "the newly formed fibers travel through the empty sheaths with extraordinary speed, deviations and retrogressions being much diminished" They reported a return of function following the use of degenerated grafts in one quarter to one half the time required when fresh grafts were used Bentley and Hill (19) summarize the advantages of degenerated grafts claimed by Ballance as follows "(1) The products of Wallerian degeneration within the degenerated graft exert a neurotropic attraction on the down-growing nerve-fibres (Cajal and Tello) (2) As the undisturbed peripheral end of a divided nerve has an intact blood supply, the products of Wallerian degeneration are rapidly removed, leaving the neurilemmal tubes empty If such a piece of nerve is used as a graft, these tubes are ready to receive new nerve-fibres immediately Whereas a piece of fresh nerve used as a graft obtains a new blood-supply only slowly, the products of Wallerian degeneration are therefore not removed for some time, and form a barrier to the down-growth of the new fibres (3) During the time taken for the vascularization of the fresh nerve-graft and the clearing of the neurilemmal tubes, the fresh graft is a foreign body, which becomes surrounded in two weeks by young fibrous tissue which blocks the ends of the graft, thus forming a barrier to the immediate entrance of axis cylinders, much time is required before the axons are able to pierce this cork of young fibrous tissue, whereas the axis cylinders can and do enter at once the freshened ends of a degenerated graft"

The experiments of Bentley and Hill, however, do not bear out these conclusions They found that a fresh graft functioned as efficiently as a degenerated one and believe that the deciding factor in obtaining good results in nerve grafting is the amount of scar tissue at the point of anastomosis They attribute the success of Duel and Ballance to the fact that "when a nerve undergoes Wallerian degeneration in situ for ten to fourteen days, it becomes firmer and stiffer, and if a graft is taken from such a nerve its cut ends tend to remain circular and patent A piece of fresh nerve, on the other hand, is soft and friable, and the cut ends, being of the consistency of butter, tend to become crushed and collapsed Satisfactory approximation of graft and nerve can therefore be obtained more readily with a degenerated graft than with a fresh one, and this advantage would no doubt be particularly valuable in grafting the facial nerve in its bony groove, where the ends of the graft and nerve are simply laid against each other and coaptation by sutures is impossible"

There is not as yet sufficient experience to determine whether or not the degenerated nerve graft is an essential element to success in the nerve grafting operation.

Operative Technic

In nerve grafting every effort must be made to minimize the formation of cicatricial tissue at the points of anastomosis, since this tissue forms an impenetrable barrier to the downward growth of new axons from the proximal into the distal segment and thus defeats the purpose of the operation. Accurate approximation with strictest

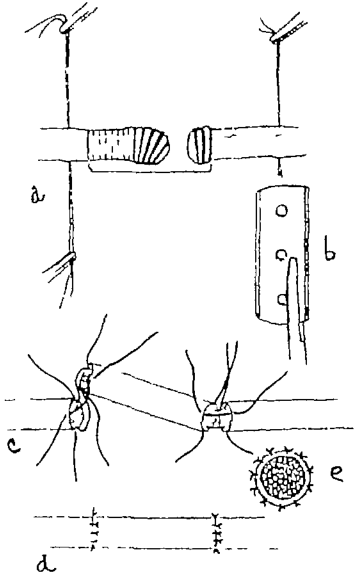


Fig 105 Nerve graft. *a*, two silk sutures passed through epineurium at corresponding points on each segment to prevent axial rotation. Nerve ends sectioned, for removal of neuroma and scar tissue, with *b* razor blade held in forceps *c* graft introduced between nerve segments, and anchor sutures placed. *d* suturing of graft completed. *e*, sectional view of graft, showing epineural sutures (After Ney)

adherence to an aseptic and atraumatic technic is therefore essential. The operation may be performed under general or local anesthesia The former is preferable because of the time involved, and because a tourniquet, if used soon becomes unbearable to a conscious patient.

The following instruments are required blunt-end nerve hooks, delicate smooth and mouse tooth forceps to grasp the epineurium, fine waxed arterial silk #00000,

disharmony of function, and lack of synchronous activity not infrequently follow These sequelae have been explained on the assumption that in the descent of the central axone into the peripheral segment some of the fibers destined to supply a given part are sidetracked to muscles of other parts The length of time required for regeneration depends upon the length of the distal segment It is estimated that regeneration takes place at the rate of 1 mm per day Usually a return of function is observed in 6 to 9 months and improves up to a year, sensation appearing before motion

Fat Grafts

The first to attempt free transplantation of fat was Neuber (1893), who employed it to build up the orbital cavity Czerny (63) (1896) reported a successful transplantation of a lipoma to reconstruct a breast Fat grafts have since been used for many purposes, for example, to elevate depressed scars, such as those following frontal sinus operations, to reshape the facial contour by filling out depressions, to obliterate dead spaces, to collapse the lung (apicolysis) in the treatment of tuberculosis and bronchiectasis, to replace brain losses, and to prevent adhesions around tendons and nerves

The use of such grafts, however, has proven only qualitatively successful They have a tendency to undergo absorption to from ½ to ¾ of their original bulk, thus preventing an accurate estimation of the proper size of the graft, as a result defects built up with this material are likely to be over- or under-corrected Moreover, the low vitality of fatty tissue renders these grafts particularly subject to infection, accordingly, they are rarely used except in combination with adjacent fascia or in the form of a flap

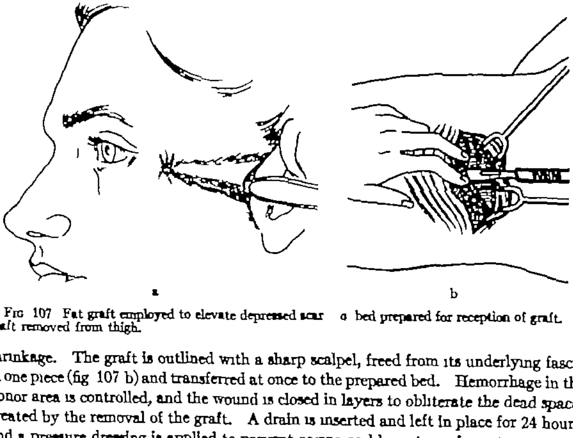
Recently Gurney (142) of the Mayo Clinic has made experimental investigations in an effort to find answers to the following questions (1) Why do fat grafts diminish in size? (2) Why do some grafts atrophy more than others? (3) Should one use multiple small pieces rather than a single large piece of equal bulk? (4) Does fat from one part of the body survive better than from another part? (5) Can fat be transplanted from one individual to another? (6) Does transplanted fat remain fat or does it become scar tissue? (7) Is the graft replaced by new fatty tissue formed by the host? He arrived at the following conclusions (1) Multiple small grafts undergo more atrophy than does a single piece of equal bulk (2) The fat which remains, if not traumatized, retains its identity This finding concurs with that of both Loeb (212) and Lexer (208) Davis and Traut (76), on the other hand, believe that none of the transplanted fat survives but is replaced by fat from the host tissue (3) Only ¼ to ½ of the graft remains The reduction in size is attributed to degeneration and is definitely related to the amount of trauma to which the graft was subjected prior to transplantation (4) The original fat which is removed for transplantation is not replaced

Operative Technic

Preparation of Recipient Area. The recipient area is aseptically prepared, draped, and anesthetized If there is an existing scar, access to the defect is gained through an opening secured by its excision, otherwise, the defect is reached through an incision

at some inconspicuous site. For example, in the case of a depressed malar bone, access may be gained through the hair line of the temporal region, and in mandibular defects, through one below the margin of the mandible. Following the initial incision, the skin is undermined to form a pocket large enough to receive the graft without tension (fig 107-a) Hemorrhage must be absolutely controlled, since the formation of hematomata will cause a loss of the graft Hemostasis is best effected by pressure with hot wet packs.

Removal of Graft. Before undertaking the removal of the graft, the operating personnel effect a change of attire and new instruments are supplied, or better, the graft is removed by an assistant while the recipient area is being prepared. The transplant may be taken from the abdomen, thigh, or gluteal region. The skin is incised over the selected donor site along Langer's tension lines, the edges are picked up with dural hooks or traction sutures, and subcutaneous undermining is carried out in a superficial plane for a distance sufficient to expose a section of fat approximately four times the size necessary to fill the defect, in order to compensate for subsequent



a b

Fig 107 Fat graft employed to elevate depressed scar *a* bed prepared for reception of graft. *b* graft removed from thigh.

shrinkage. The graft is outlined with a sharp scalpel, freed from its underlying fascia in one piece (fig 107 b) and transferred at once to the prepared bed. Hemorrhage in the donor area is controlled, and the wound is closed in layers to obliterate the dead spaces created by the removal of the graft. A drain is inserted and left in place for 24 hours, and a pressure dressing is applied to prevent oozing and hematoma formation.

Placing of Graft. The recipient bed is dried, and the graft, held in a forceps, is introduced with as little handling as possible, since even slight trauma may lead to infection. Frequently it is convenient to draw the graft into the cavity by means of a pilot suture one end of which has been attached to the graft and the other made to emerge through the skin at the distal end of the pocket. With the graft in place, the incision in the skin is closed accurately with on-end mattress-sutures of horsehair, drainage being omitted. A light pressure dressing is applied and a careful watch kept for evidence of infection and hematomata. The skin sutures are removed in 48 to 72 hours.

Fascia Grafts

Fascia is an excellent material for grafting purposes, and since the introduction of these grafts by Kirschner (188) (1909) and the development of a satisfactory technic by Gallie (119) (1924) they have been used to advantage in practically every branch of surgery Fascia is easily obtained in almost any desired quantity, it can be removed without impairment of function, and it is easy to manipulate When transplanted, it accomodates itself to the adjacent structures even under unfavorable conditions, it is resistant to infection, is able to obtain sufficient nutrition from the surrounding lymph spaces to retain its viability until a new circulation is established, tends to maintain its original structure and resists absorption, and finally, because of its firmness and toughness, holds sutures well and withstands great strain

The *source* from which the fascia is to be obtained will depend upon what is demanded of it For instance, where the indication is to fill deep cavities abdominal fascia is chosen because of the abundance of fat which may be taken with it, whereas when tensile strength is required, the material of choice is fascia lata

Inasmuch as there is a regional difference in the texture, thickness, and tensile strength of fascia lata, it may not be out of place to review a few of its pertinent anatomic features Fascia lata, or the deep fascia of the thigh, is a thin, firm, glistening aponeurosis situated between the panniculus adiposus above and the muscles below It takes the form of a cone, being attached above to the iliac crest, ischium, sacrosciatic notch, symphysis pubis and inguinal ligament, and inserted below into the patella, condyles of the tibia, and head of the fibula It comprises two layers The superficial layer, composed of longitudinal fibers, is firmly attached to the overlying fat by means of areolar tissue, which makes the fascia slippery and somewhat difficult to handle The deep layer, composed of transverse fibers, is loosely attached to the muscle beneath, and when freed it tends to curl toward the deep surface On the anterior surface of the thigh the fascia is thick and strong, on the posterior and medial aspects it is quite thin, and on the lateral surface it is considerably thicker and has great tensile strength Here it is known as the iliotibial band This band is attached above to the iliac crest and below to the condyles of the femur and tibia Gratz (140), in a study of the tensile strength and elasticity of fascia lata, found the breaking tension in a strip $\frac{1}{64}$ to $\frac{1}{32}$ of an inch thick and $\frac{3}{8}$ of an inch wide to be 55 pounds Thus fascia lata is almost as strong as soft steel, weight for weight Orrin (260) states that a loop of fascia can, without breaking, suspend a weight of 90 pounds, whereas a loop of periosteum of the same size and under the same circumstances cannot sustain a weight exceeding 13 pounds

The histologic changes which occur in fascia following its transplantation are not unlike those found in skin Immediately after transplantation the fascia adheres to the surrounding tissue, and the graft shows a transient inflammatory reaction, but in time, with the establishment of new vessels, this reaction subsides, and the fascia resumes its original morphologic integrity and tensile strength

Clinical Application

The indications for fascia transplantation are many and varied, and may be summarized as follows:

(1) To bridge a gap, such as a hernial ring or a fistula, or to reconstruct a defect

in the trachea, esophagus, pleura, or diaphragm. For this purpose Gallie (119) bridges the defect by weaving strips of fascia lata into the recipient tissue in such a manner that the strain falls upon the transplant. Stewart (323) cuts the fascia graft in the form of a sheet, spreads it well over the edges of the defect, so as to obtain a broad area of adhesion, and fastens it securely to the surrounding tissues. Fascia lata with an attached layer of fat is used to replace losses of the pachymeninx, but in this capacity it is not entirely satisfactory, as it fails to prevent subsequent adhesions. However, it does lessen the danger of cerebral herniation

(2) To serve as a cock up splint following facial paralysis. During the stage of recovery of nerve function subcutaneous loops of fascia lata prevent overstretching of the muscles and in the case of permanent paralysis they serve as a permanent mechanical support for the sagging tissues. The technic of their application is described in the section dealing with facial paralysis (p 1026) Fascia is similarly used to support prolapsed viscera and to create sphincters (fig 111)

(3) To build up the contour of the body When used for this purpose, it is often of advantage to cut the graft with a layer of adherent fat. Such a graft is superior to one composed of fat alone, in that it retains its character, is better able to resist absorption, and will 'take" even in the presence of a considerable amount of scar tissue.

(4) To reconstruct tendons and tendon sheaths Fascia is not well adapted for this purpose even though a layer of adipose tissue be included, as it has a tendency to form adhesions. (To reconstruct a tendon a sheet of fascia of the required size is secured anchoring sutures are passed through each of its four corners, and the transplant is sutured to the divided tendon ends in the form of a cylinder) Fascia finds wide application, however, in the strengthening of joints subject to habitual dislocations, and in the transfer of the action from paralyzed to active muscles.

(5) To relieve ankylosis and to construct false joints. In the former case the joint is exposed, the pathologic tissue causing the ankylosis is removed, and a strip of fascia lata is placed between the articular ends to prevent their reunion. In the latter, the bone is divided below the articulation the ends are rounded to facilitate their movement on each other, and the fascia strip is interposed in the line of the osteotomy The technic for both procedures is described in Chapter XVII

(6) To serve as living suture material. A strip of fascia lata 6 mm. wide is threaded into a large-eyed Gallie needle and tied over itself with fine silk to prevent its slipping The end of the suture is similarly tied to avoid fraying The first stitch is passed through the margins of the defect and anchored in place by means of a slip knot. The suturing is continued, every third stitch being locked because of the slippery character of the material. When the suture is completed, the needle is removed and the terminal end of the fascia is split in two One end is passed under the main suture and tied to the other end and to guard against slipping, the knot is transfixed either by a silk or catgut suture. Gallie s technic is shown in Figure 110

Operative Technic

The method of preparing the recipient bed varies with the use to which the fascia is to be put and will be described in the respective sections.

Procuring of Fascia Lata. The skin of the thigh is aseptically prepared, draped,

and anesthetized in the usual manner The fascia graft may be obtained in one of two ways: (1) by the use of a fascia stripper (fig 108), or (2) by the open method.

(1) Fascia procured by the use of a fascia stripper incurs but slight damage to the thigh At a point just below the great trochanter on the outer side of the thigh a longitudinal incision 2 to 3 cm long is made through skin and subcutaneous fat to expose the iliotibial band, which may be recognized by its white glistening appearance With a sharp knife a strip of fascia 1 2 cm wide is separated from the overlying soft

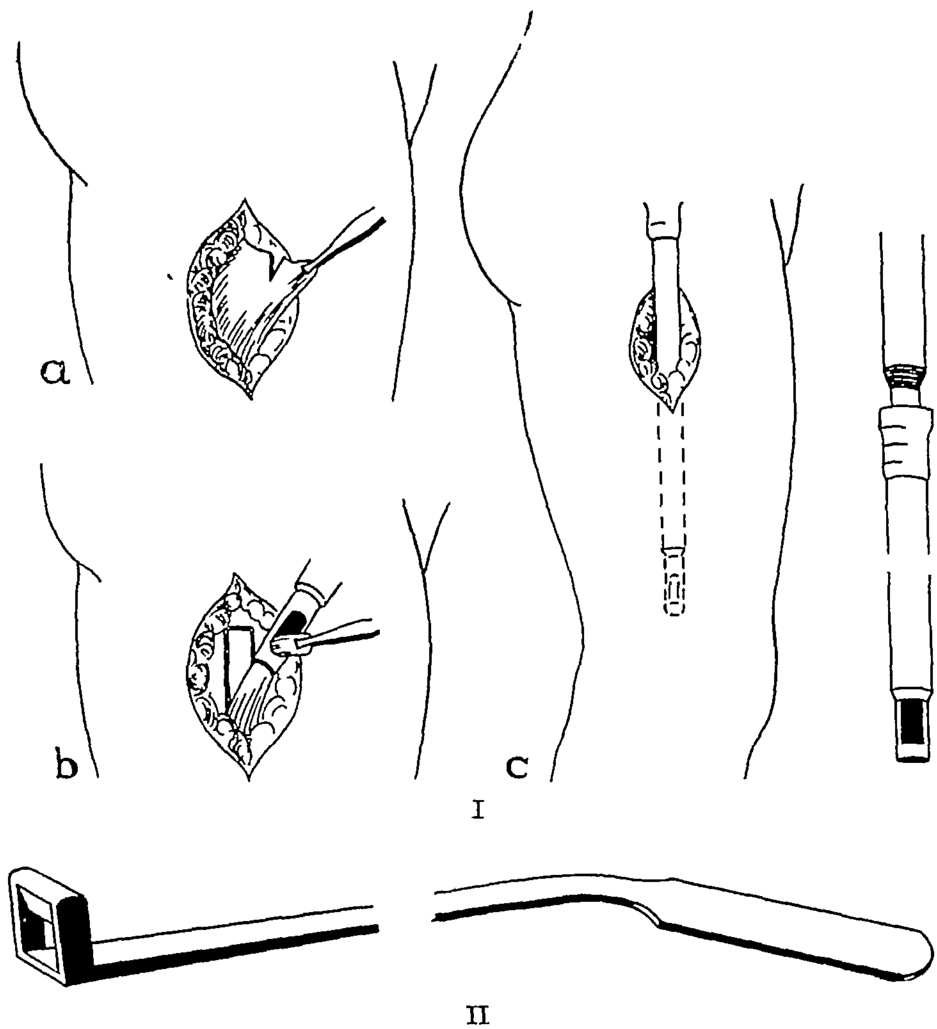


FIG 108 Procuring of fascia lata *I*, with Masson's fascia stripper *a*, fascia lata exposed through incision below great trochanter and nicked to facilitate its introduction into eye of instrument *b*, fascia threaded through eye of stripper, and end held taut with forceps *c*, stripper forced down toward knee, until section of desired length has been raised Fascia freed with cutting end of stripper Insert shows Masson's stripper *II*, Patey's stripper For details of its use, see text

tissue and threaded through the eye of the stripper With this small flap held taut in a pair of forceps, the stripper is forced down in a straight line toward the knee until a section of the desired length has been raised The graft is then freed with the cutting end of the stripper

Masson (238) has devised an excellent instrument "made of two steel tubes, one of which is slightly longer than the other, has a handle at one end and an opening close to the other, and fits inside the other tube This outer tube has a cutting edge at its

lower end After freeing up, through the small incision on the upper outer aspect of the thigh, a piece of fascia sufficiently wide to make as many sutures as I expect will be necessary , it is inserted through the opening in the end of the stripper, by careful manipulation this strip can be freed down to the insertion just above the knee The cutting end of the outer tube is used to cut the strip free." (Fig 108-I.)

A simpler instrument is Patey's (270) modification of the Austin stripper, in which the cutting blade runs transversely across the top (fig 108-II) With this instrument, the graft is cut as follows An incision 3 to 4 cm long is made through skin and fat at the lower end of the thigh down to the fascia lata, and a strip of the required width is dissected up and threaded through the window of the stripper The instrument is then forced up and when a graft of the required length is obtained, it is severed with the transverse cutting blade of the instrument.

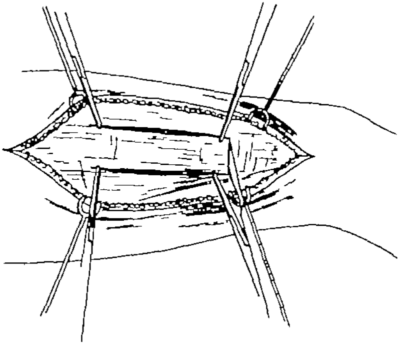


FIG 109 Procuring of fascia lata by open dissection. Fascia exposed through longitudinal incision on lateral aspect of thigh. Graft outlined by 2 longitudinal incisions, ends of which are joined by transverse incisions. Section stripped from underlying muscle.

(2) If a wider graft of fascia is required than can be cut with the stripper, it must be removed by open dissection, even though this may leave a large scar Beginning at the anterior border of the base of the great trochanter an arched longitudinal incision about 30 cm. long carried through skin and subcutaneous fat, is made on the lateral aspect of the thigh The fascia is gently cleared for the required distance by blunt dissection, and an appropriately sized graft is outlined. When possible, the graft is removed in the form of an ellipse, in order to facilitate closure of the remaining gap When such an excision is impracticable, the graft is removed by two longitudinal incisions whose ends are joined by transverse incisions (fig 109) Anchor sutures are applied at cardinal points, and the graft is stripped from the underlying muscle. The remaining wound, if long and narrow is approximated by a few catgut sutures. If the gap is too wide for direct approximation without undue tension, it is left open. This does not seem to result in any functional disturbance, the slight

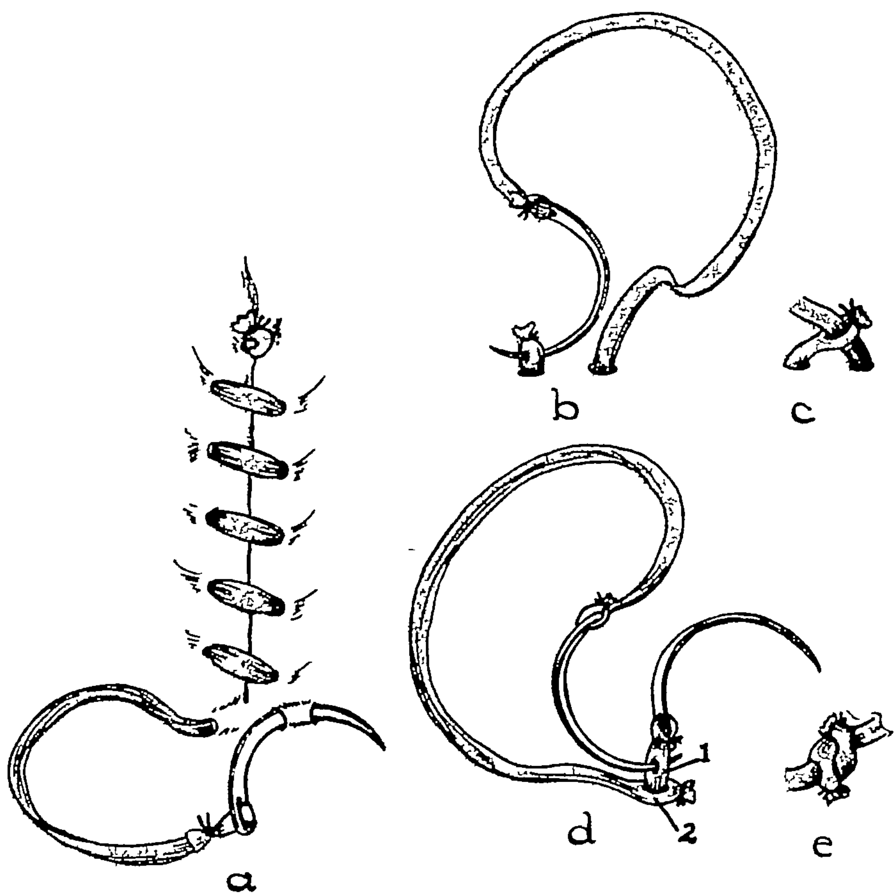


FIG 110 Use of fascia lata as living suture material a, silk ligature tied around tail of suture, to prevent fraying First stitch passed through wound margins and anchored by slip knot b, slip knot formed by passing needle through tail of suture c, slip knot tightened d, method of joining one suture to another, when more than one length of fascia is necessary to close wound Needle of suture 1 passed through tail of suture 2 Needle of suture 2 then passed through suture 1 e, joining of sutures completed (Gallie)

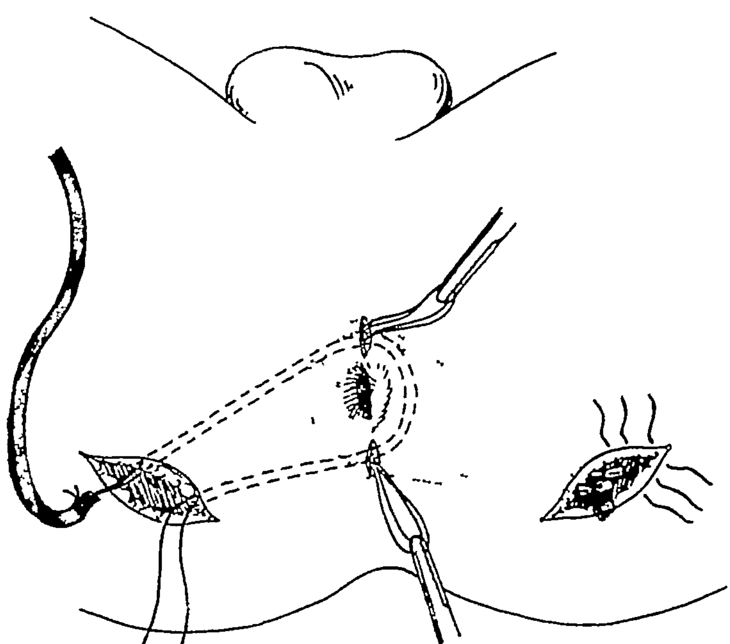


FIG 111 Use of fascia lata for creation of sphincter, to relieve anal incontinence Fascia lata loop on left side in position Guide sutures in place, to draw fascia lata loop through on right side (Stone)

bulging of muscle which can be seen through the defect disappears in time. The wound in the overlying soft parts is closed and dressed in the customary manner

Placing of Graft. As soon as the graft is secured, it is manipulated into the defect by means of the anchor sutures previously passed and is fixed with these sutures to corresponding points in the bed. Marginal approximation is then completed by additional sutures of silk or catgut, placed in such a manner as to submit the graft to slight tension The subcutaneous structures are united over the graft in layers, and the skin is closed with on-end mattress-sutures of silk. To insure a greater security of the wound, Wheeler (360) advised that it be made air and water tight, and to accomplish this he employed the "halving technic," a principle used in carpentry, i.e., in order to secure a stronger joint, instead of bringing the boards together end to end, their thickness is divided in half and the divided ends overlapped (p 836)

The technic for the specific application of fascia grafts, as in facial paralysis, blepharoptosis, arthroplasty, closure of cranial and dural defects, etc., will be described in the respective sections.

Tendon Grafts

Tendon grafting is indicated following a loss of tendon continuity in which the defect is too great to permit of direct approximation of the stumps, and when the tendon is so intimately fused with surrounding structures that no prospect of function is offered by its release. These grafts "take" well and will even hypertrophy after transplantation to compensate for any strain placed upon them. Bunnell (40) states "Free tendon grafts remain alive as such. Their surfaces and much of their depth subsist at first on surrounding lymph and soon acquire a blood supply of their own. Some patchy necrosis occurs within a graft, but this eventually becomes substituted by normal tendon tissue. In the first three weeks the graft becomes swollen and edematous, but this condition subsides and in three months the graft closely resembles normal tendon both in the gross and microscopically"

The difficulty in tendon grafting lies in providing a gliding mechanism, without which the graft will adhere to surrounding structures and defeat the purpose of the operation. Tendon grafts are best obtained from the palmaris longus, the sublimis, and the long extensor tendons of the toes, inasmuch as these tendons can be transplanted with their paratenons intact, and their removal occasions little impairment of function. When unsheathed tendon grafts are used, the gliding mechanism may be restored by surrounding the graft with a thin layer of fat obtained from around the triceps muscle or tendo achillis. The use of foreign bodies to prevent adhesion, such as segments of veins, fascia, silver foil, etc., has not proven successful.

As in all grafting operations, transplantation should not be undertaken until all signs of infection have ceased, the parts have been made soft and pliable, and overlying scar tissue, if present, has been excised or replaced by healthy tissue.

Technic. The recipient area is aseptically prepared and draped in the usual manner and a tourniquet applied. An incision is made extending well above and below the probable site of injury and is arched so that the suture line will not overlie the graft. The tendon is then exposed by careful dissection. All scar tissue is excised and the tendon ends revivified in the manner described on page 290 When bleeding has been controlled, the defect is measured, so that an appropriately sized graft may be cut.

The donor tendon is then exposed, and a section of the required length is excised, transferred immediately to the prepared bed, and sutured to the proximal and distal stumps of the recipient tendon As tendon grafts are prone to contract, they should be long enough to fill the gap with the recipient ends in the position of maximum separation The technic of suturing is the same as that employed in end-to-end approximation (fig 112) When the distal stump is short, it is advisable to excise it

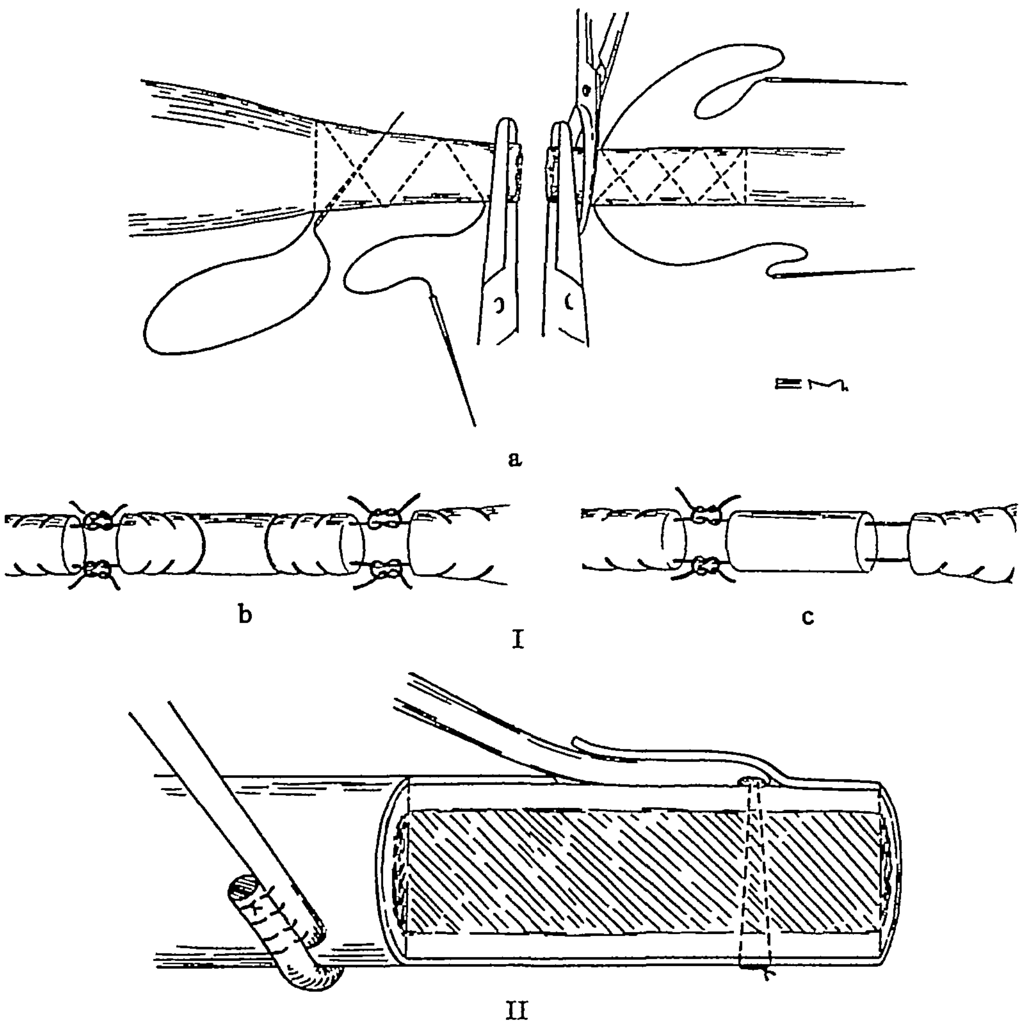


FIG 112 *I*, Bunnell's method for suturing tendon grafts *a*, technic of passing sutures through proximal and distal stumps prior to introduction of graft. Ends held by forceps cut off *b*, method of immobilizing long tendon graft. *c*, method of immobilizing short graft For technic of suturing, see "Wounds" *II*, methods of attaching tendon graft to bone when distal end of tendon stump is too short (Kirschner)

and attach the graft directly to the bone by passing it through drill holes and suturing it to the periosteum The after-care is the same as that employed in end-to-end approximation

Gland Grafts

The transplantation of glands with a retention of their function, if practical, would obviously have wide surgical application in the treatment of glandular deficiencies

arising from congenital absence, disease, or operative removal, especially if heterogenous material could be employed. This type of grafting, however, is at present in the experimental stage, and its practical application still remains a hoped for objective The transplantation of glandular tissue from animals to man has been generally discouraging, although Voronoff (348) claims "success' with this type of transplant. Homografting and autografting, on the other hand, have offered considerable promise, and their feasibility has recently been demonstrated by many investigators.

Stone, Owings, and Gey (325, 326) have transplanted live, functioning grafts of thyroid and parathyroid glands in both animal and man. The donor tissue is removed under strict asepsis and divided into fragments 1 to 15 mm. in diameter These segments are planted on a tissue culture medium and watched for evidence of contamination. If at the end of a day or two they prove to be free of contamination, they are transferred to a medium of the recipient's serum and plasma and cultured for a period of from 2 to 4 weeks, the media being changed from time to time. When ready, the grafts are picked up in a pipette containing normal salt solution and are injected into a canal previously prepared in the axilla or groin, in close proximity to a blood vessel so that they may quickly take on a new blood supply

Autotransplants have been employed with considerable success in cases of para thyroid, ovarian, and uterine deficiencies. Cutler and Schmitker (61) advise as a precaution against tetany that following all operations on the thyroid gland the surgical specimen be carefully examined for the presence of the parathyroids, which if found are gently cut away from the gland with small scissors and re-embedded into the belly of the sternomastoid muscle. To overcome the cardiovascular, metabolic, and psychic phenomena arising from bilateral oöphorectomy and to relieve tubular sterility, the autotransplantation of ovarian tissue has been suggested. In the former case, Shaw removes from the interior of the excised ovary a piece of tissue appearing normal This he cuts into pieces 2 to 3 mm. in diameter and inserts them into the rectus muscle. Tuppier states that these grafts "take" in 67 per cent of the cases. For the relief of tubular sterility it has been suggested that the ovary be transplanted into the uterus on a pedicle.

Autotransplantation of the endometrium following hysterectomy was first suggested by Bouwdijk (29, 30) in order to retain the internal secretion of the uterus and thereby postpone the onset of menopause. Following a supravaginal amputation a section of the mucosa 1 to 2 cm. in diameter and 2 to 3 mm. in thickness is sutured into the cervical stump In cases of total hysterectomy Schmid (304) inserts into the vaginal wall several small pieces of the membrane 2 to 5 mm. in diameter

LeFort (201) reports successful results following transplantation of human thyroid tissue into a child with deficient thyroid secretion "About one half of the right lobe of the thyroid was obtained from an executed criminal and about two thirds of this tissue was immediately transplanted into the abdominal rectus muscle of the child. Four days after the operation the child had lost much weight and its facial expression was already greatly changed. Dentition, which had been greatly retarded before the intervention, was accelerated. The modification of the intelligence was surprising From the point of view of the physical and mental development, the efficacy of the thyroid graft was gradually lessened as the years advanced."

The most satisfactory way to procure an epithelial lining is to cover the under surface of the flap with a full thickness or split-skin graft some time before bringing it into the defect The flap is temporarily raised, covered by the graft, raw surface to raw

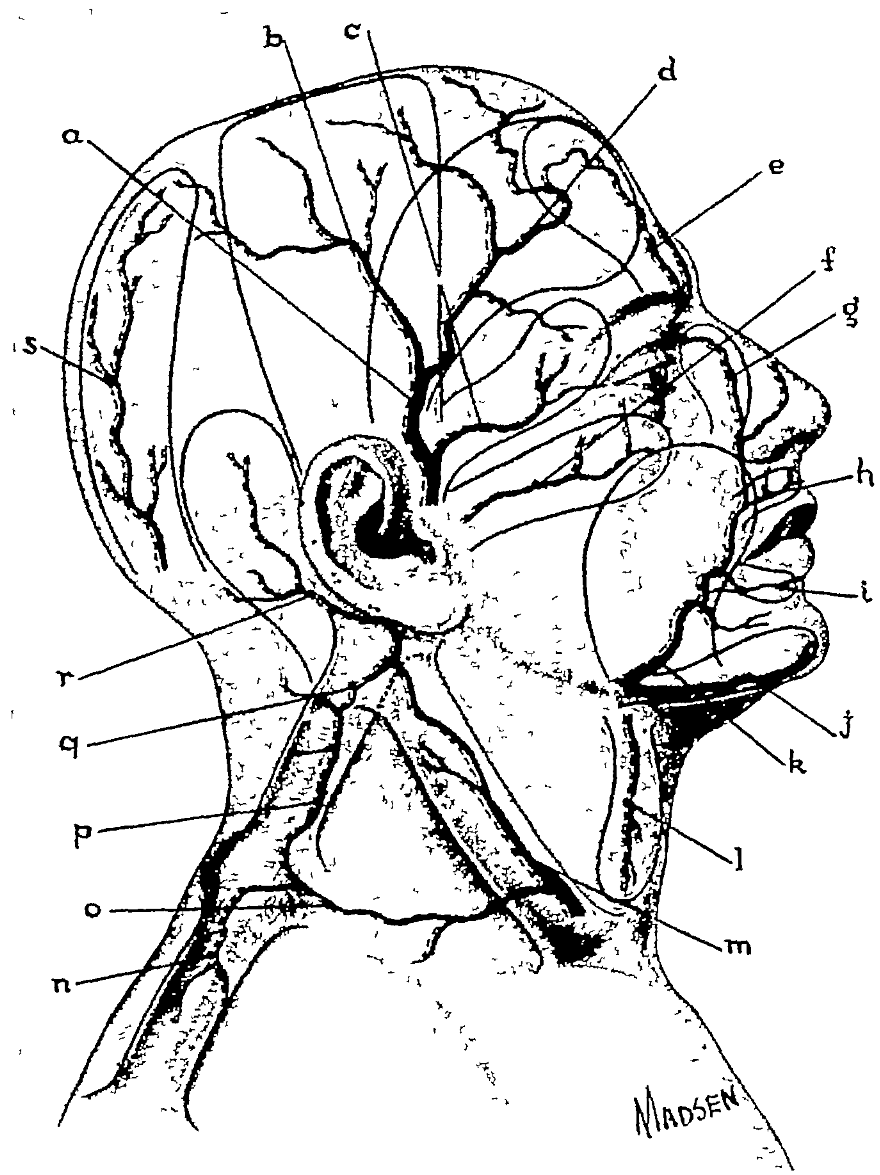


FIG 113 Desirable sites for procuring flaps from head and neck Maximum nutrition assured by inclusion of blood vessel in pedicle *a*, superficial temporal artery *b*, parietal branch of superficial temporal *c*, orbital *d*, frontal branch of superficial temporal *e*, frontal *f*, transverse facial *g*, angular *h*, superior labial *i*, inferior labial *j*, submental *k*, external maxillary *l*, superior thyroid *m*, ascending cervical *n–o*, superficial cervical *p–q*, cutaneous branches of occipital *r*, posterior auricular *s*, occipital (Spalteholz)

surface, sutured back into place, and a pressure dressing applied After a period of two or three weeks the flap is again raised, carrying the skin graft on its under surface as a lining If the size of the flap is such as to prevent approximation of the donor area directly, this area can be resurfaced at the time that the flap is lined.

Methods of Transfer

The flap may be transferred into the defect either directly or indirectly, depending upon the distance to be bridged between the donor site and the area to be repaired.

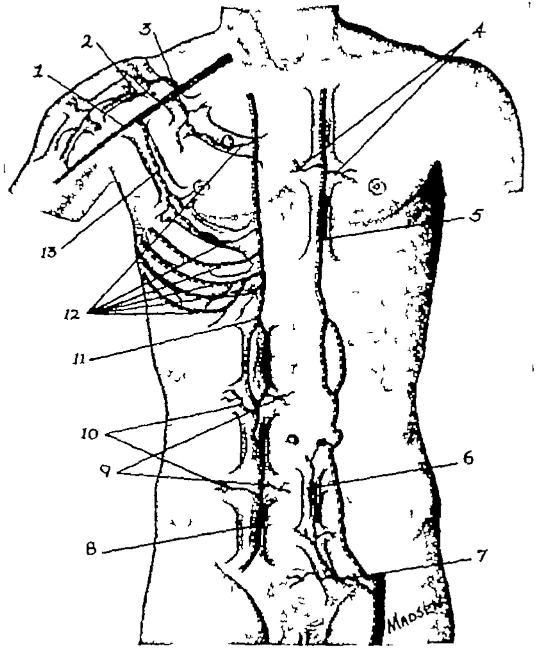


Fig 114 Desirable sites for procuring flaps from anterior trunk and abdomen. Maximum nutrition assured by inclusion of blood vessel in pedicle. *1* acromiothoracic artery *2* deltoid. *3* pectoral branch of acromiothoracic. *4* perforating branches of internal mammary *5* internal mammary *6* cutaneous branch of deep epigastric. *7* superficial epigastric (from femoral) *8* deep epigastric. *9* cutaneous branches of deep epigastric. *10* cutaneous branches of superficial epigastric. *11*, superior epigastric. *12* anterior intercostals. *13*, long thoracic. (Manchot)

(1) **Direct Transfer** By this is understood the elevation of a flap of tissue and its implantation directly into the revivified defect, the flap by its own length bridging the space between the donor and recipient areas. This is the method of choice, as it reduces the number of necessary operations to two In the first of these the flap is

raised and sutured into the revivified defect, and in the second, 2 or 3 weeks later, the pedicle is cut (fig 119) This method of transfer, however, is applicable only (A) when the donor area is contiguous to the defect, for example, in the case of a forehead flap to repair a loss of nasal tissue, or (B) in instances where the donor and recipient

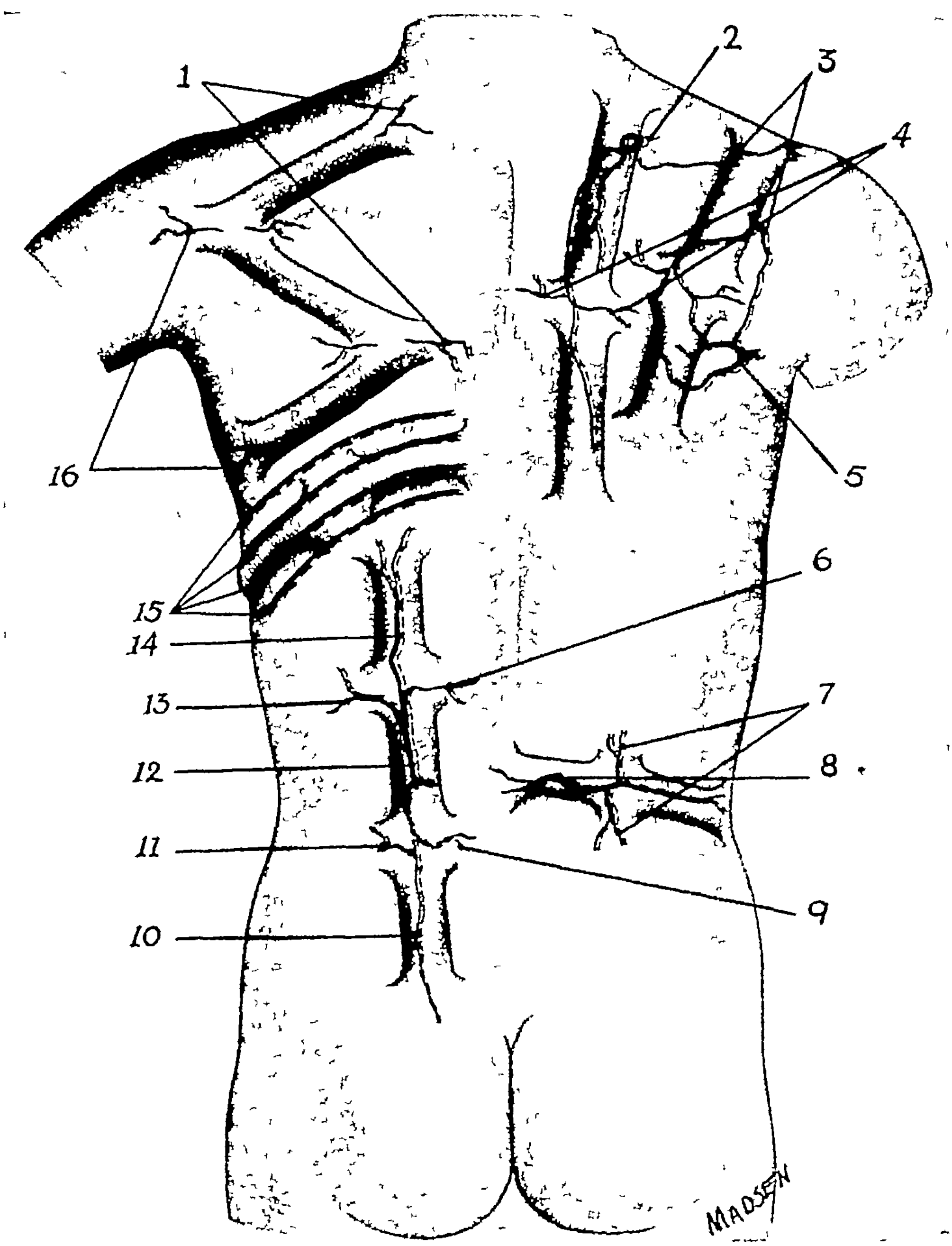


FIG 115 Desirable sites for procuring flaps from posterior surface of trunk Maximum nutrition assured by inclusion of blood vessel in pedicle *1*, dorsal cutaneous branches of intercostal arteries *2*, cutaneous branch of subscapular *3–5*, cutaneous branches of transverse scapular *6–14*, cutaneous branches of lumbar *15*, dorsal cutaneous branches of intercostals (Manchot)

areas can be approximated directly by favorable posture, either by (a) *bringing the donor area to the defect*, as when an arm flap is used to repair a loss of facial tissue (fig 120), or by (b) *bringing the defect to the donor area*, as when a hand is repaired by its insertion beneath a bridge of tissue on the abdomen (figs 121–123), or when an

amputation stump is covered by its implantation into an incision in the abdomen or unaffected leg. In either case, when vascularization has taken place, the defective member is separated from the donor area, together with enough contiguous donor tissue for the repair of the defect.

(2) **Indirect Transfer.** In the indirect method of transfer the flap is carried to its destination in stages through one or more intermediate points of attachment. This

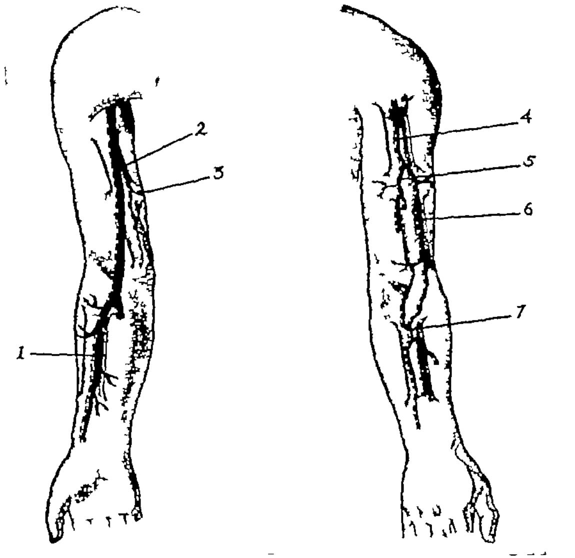


FIG. 116. Desirable sites for procuring flaps from upper extremity. Maximum nutrition assured by inclusion of blood vessel in pedicle. *1*, cutaneous branches of radial artery; *2*, brachial artery; *3*, cutaneous branches of brachial; *4–6*, cutaneous branches of profunda brachii; *7*, cutaneous branches of dorsalis. (Manchot.)

method is resorted to when the donor tissue is so located that it cannot be brought to the defect even by favorable posture, as for example in the case of an abdominal flap employed to repair a facial loss. The transfer may be accomplished in one of three ways. (a) *Successive Migration* (*Caterpillar Flap, Jump Flap*). This method consists in raising a bridge of tissue and suturing the free margins together in the form of a tube. When the circulation has become established, the distal pedicle is cut and implanted into a prepared area nearer to the defect. This process is repeated,

alternate pedicles being cut, until the flap has reached the part to be repaired Transfer by successive migration was first described by Roux (300) (1854) who was compelled by circumstances to employ it in the reconstruction of a defect of the lip and chin Halsted (152) later referred to this procedure as "waltzing the flap," and it was also described by Israel, Hahn, and Hacker (148) as a "Wanderlappen" (fig 124) (b) *Creeping Flap* This method consists of raising a flap and implanting its free end "inchworm"-fashion in the vicinity of the pedicle After vascularization, the other pedicle is divided and the flap is opened up and swung into the defect The obvious objection to this method of transfer is that the raw area is thereby left exposed to infection and cicatricial tissue formation (c) *Intermediate Carrier* (Schrody, 1888). By this method the donor tissue is brought into the defect through the medium of a movable intermediate host, such as the wrist For instance, to repair a neck defect with abdominal tissue, a flap is raised and implanted into a prepared bed in the wrist where it is allowed to remain until the blood supply becomes established The abdominal pedicle is then cut, the flap attached to the carrier is brought to the neck and sutured into the defect, the arm being immobilized until vascularization takes place (fig 125) When the flap becomes established in its new location, the pedicle on the wrist is cut, the remaining part of the flap fitted into its bed, and the arm gradually lowered

Measures to Enhance Nutrition of Flaps

The nutrition of the flap is of paramount importance, and when circumstances are such that the blood supply is questionable, the surgeon may resort to various measures in order to enhance it The underlying principle in each case is a gradual, rather than a sudden, reduction of the blood supply, so as to permit the flap to become accustomed to a decrease in nutrition before it is transferred to its new bed This process is called "delaying " It is indicated when the circulation of the donor site is poor, as in the case of patients of advanced age and those suffering from constitutional diseases It is also advisable when the proposed flap is to be especially large, long, and narrow, angulated, or irregular in shape, when the flap must be cut across the blood supply, when the amount of subcutaneous tissue must be reduced to a minimum, and when the donor tissue is to be taken from a remote part of the body and transported in stages to the recipient area

The means of enhancing the nutrition of the flap are as follows

(1) **Employment of Two or More Pedicles and Raising the Flap in the Form of a Tube.** A bridge of skin and subcutaneous tissue is raised and the long margins are sewn together, the flap being left attached to the donor site by its two extremities The result somewhat resembles the handle of a satchel, and a detailed description of its construction and application will be given later In the case of unusually long flaps it may be advisable to raise and tube a portion of the proposed flap at one operation, wait for vascularization to become established, and then gradually extend the tube to the desired length (fig. 129-II, c) Or the extremities of the tube may be formed at one operation and the tube completed at another time

To further assure the viability of the flap, several pedicles may be employed (fig 129-I) Two parallel incisions are made in the usual manner, an interval of 5 mm. of skin is left untouched and the incisions continued for another 9 cm The inter-

vening tissue is raised and tubed, the untouched skin serving as pedicles (299) The number of incisions and intervals may be increased or decreased, depending upon circumstances Webster (355) modified the above procedure by making an uninterrupted incision along the full length of the proposed tube on one side and leaving a wide bridge of uncut skin in the midportion of the other (fig 129-II, a) "A single long

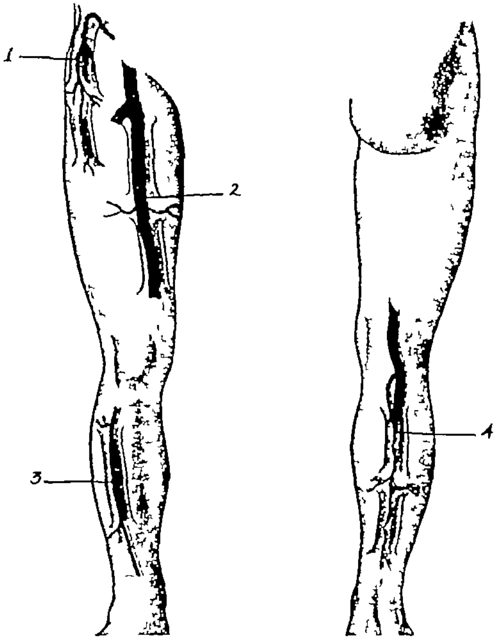


FIG 117 Desirable sites for procuring flaps from lower extremity Maximum nutrition assured by inclusion of blood vessel in pedicle. *1*, superficial circumflex iliac artery *2* cutaneous branches of femoral. *3* anterior tibial. *4* perineal. (Manchot)

incision is made along the anterior line of the full length of the tube it is desired eventually to form. The posterior incision, staggered by starting somewhat higher than the anterior incision, is carried out for its full length with the exception that in its midportion a fairly wide bridge is left uncut. Performing dissection through the anterior incision the tissues beneath the tube to be raised and beneath

the skin at each side of the defect are readily undermined between the superficial and the deep layers of the deep fascia . . The opposing skin edges are then approximated so as to form an upper and a lower tube" The advantages claimed by Webster are

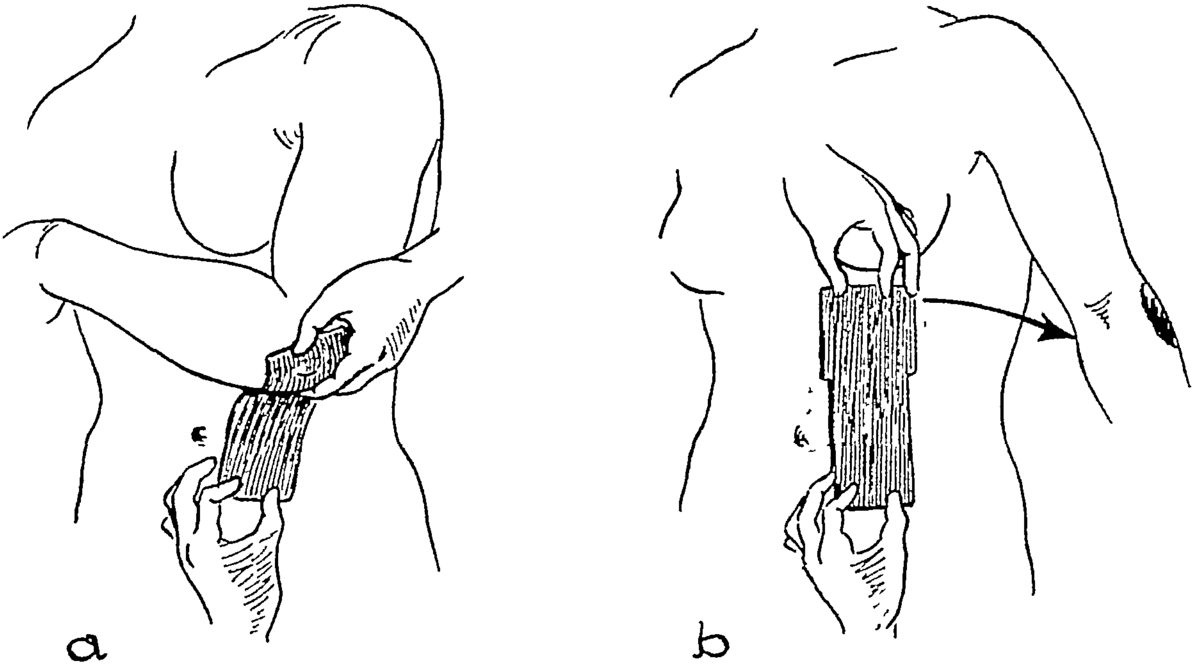


FIG 118 Fashioning of abdominal flap, to cover defect on elbow *a*, elbow flexed and approximated to side, bringing defect as close as possible to donor area One end of gauze strip fitted to defect, and other end laid loosely over abdomen *b*, arm released, and remainder of pattern placed over abdomen For details, see text (Gillies)

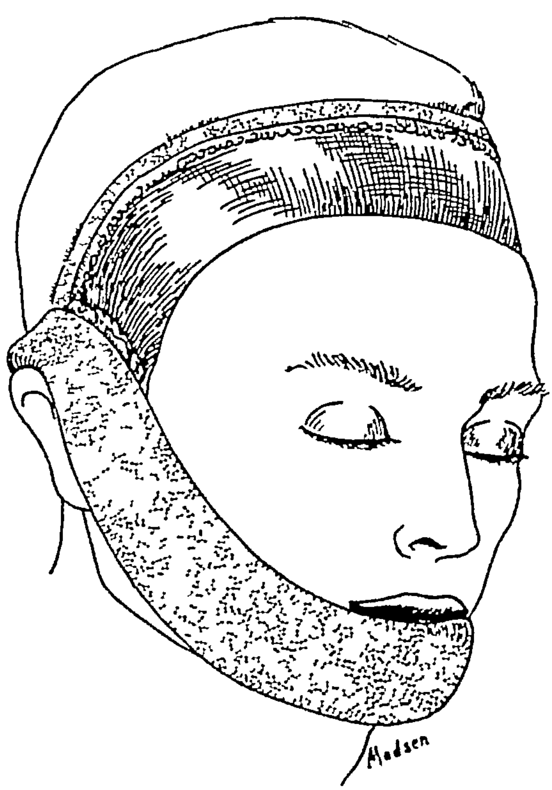


FIG 119 Direct transfer of flap, wherein flap by its own length bridges space between donor and recipient areas

summed up as follows "(1) Wide undercutting of all areas is much more readily accomplished than in any of the preceding modifications because of the length of the anterior incision. (2) The surface of the superficial layer of the deep fascia and many of the vessels may be studied through the large anterior wound so that those vessels necessary for nutrition may be preserved. (3) The bridge between the posterior incisions may be safely narrowed so that only a small interval may have to be left. The narrower the bridge the less extensive will be the subsequent operation of forming a single long tube. (4) It may be possible to perform this second operation under

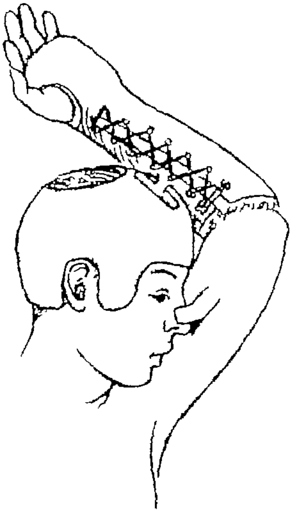


FIG 120 Direct transfer of flap made possible by favorable posture Donor area brought to defect Arm immobilized to head. (D'Archaac)

local anesthesia if the bridge is sufficiently narrow (5) By this procedure, the tissues on both sides of the defect are brought together practically as fully as when the full length tube is made at the usual single operation, permitting easier secondary closure of the wounds than is possible by other modified procedures."

(2) **Partial or Complete Separation of Flap and Repositioning It in Its Bed before Transfer** The flap is outlined by an incision through the skin and subcutaneous tissue, or its blood supply is further interrupted by partially or completely separating it from its bed by undermining (24) In the latter case, the flap is replaced and left undisturbed until enough time has elapsed for it to become vascularized but not reattached to its base i e. a week or ten days. In order to preclude the possibility

of reattachment Croft (60) suggested that a piece of rubber tissue cut to pattern be placed between the flap and its bed, thus forcing the flap to receive its nutrition from the pedicle only (fig 129-III) To prevent contraction during this period the margins should be coapted by sutures When collateral circulation has developed, the flap is again freed and this time shifted into the bed prepared to receive it Blair states that even should such a flap slough after transplantation, the sloughing will be less marked than if it had been transferred directly

A wider margin of safety may be ensured by combining the above-mentioned methods At the first sitting a bridge of tissue is raised and resutured into its bed, at a second sitting, a week or ten days later, the flap is again raised and tubed

(3) **Intermittent Compression of the Pedicle** Before the transplantation of a double-pedicled flap, the pedicle destined to be cut may be intermittently compressed so as to force the flap to develop an anastomosis and receive its entire nutrition from the other pedicle (fig 129-IV) After transplantation the remaining pedicle may likewise be compressed, thus forcing the flap to receive its entire sustenance from its new bed. Compression is accomplished by constricting the pedicle for an hour twice daily with tape, thin rubber tubing, or a soft clamp for a week before severance On this same principle the pedicle may be notched a little each day until it is completely separated (143)

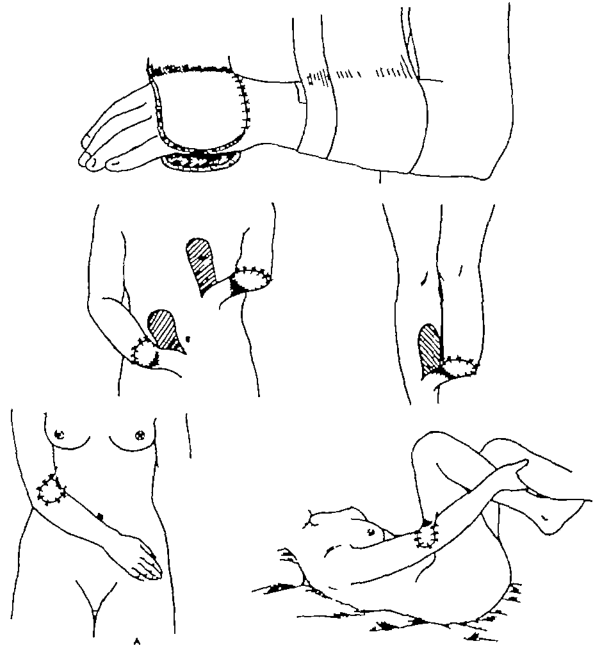
The main objections to the process of "delaying" the flap are the additional operations necessitated thereby and the lengthened hospitalization and greater expense involved

Choice of Donor Site

The tissue destined to replace the loss may be obtained from any part of the body, provided the part is well nourished and sound The flap should be planned whenever possible to carry not only a main artery (figs 113–117) for the supply of nutrition, but also its accompanying vein for the removal of excretions, since an inefficient outlet diminishes the effectiveness of the arterial current by blocking the capillaries and may cause the flap to slough It is inadvisable to choose a donor site in the midline of the body because of the naturally poor blood supply in this location. The donor tissue must be free from scars, as these have a tendency to cut off the circulation, and even in cases in which the flap remains viable make for slow and unsatisfactory healing Tissues previously exposed to x-ray or radium are best avoided because of their lowered resistance

In addition to vascularity there are other factors which influence the selection of the donor site. The esthetic and functional demands of the part to be repaired must be considered On exposed parts, such as the face, the donor skin should be chosen with regard to color, texture, thickness, and hairiness, so that it may blend with the parts that will ultimately surround it Flaps taken from the immediate neighborhood furnish a better match than do those from a more distant locality, but this desirable feature is often counterbalanced by the secondary defect resulting from their use. Therefore, whenever contiguous flaps are employed, an area should be selected where the secondary defect will be as inconspicuous as possible Frequently it may be concealed in the hair or in a natural fold If the defect involves a hirsute region, as, for instance, the bearded part of the face or the eyebrow, a hair-bearing donor area

is sought On the other hand, hair bearing flaps used *on non hairy surfaces may be* a source of distress and embarrassment to the patient Occasionally, however, the *use of hair* bearing flaps in non hairy regions is unavoidable, and under such circumstances the hair must be removed either before or after transplantation. *Of the* many methods suggested none are entirely satisfactory X ray and radium have



A

B

FIG. 121. Direct transfer of flap made possible by favorable posture. Defect brought to donor area. (Poncet and Birger)

been advocated, but the heavy dosage required to destroy the hair interferes with the nutrition of the flap Electrolysis of the hair follicles is probably the most efficient method, but it is practicable only where the hairs are few Réthi (290) advises raising the hair-bearing skin as a flap, trimming from its under surface the layer containing the hair follicles (fig 130), and then replacing the flap ten days prior to its use

The thickness of the donor site should approximate as nearly as possible that of the part to be restored For instance, the thick skin of the back or abdomen would scarcely

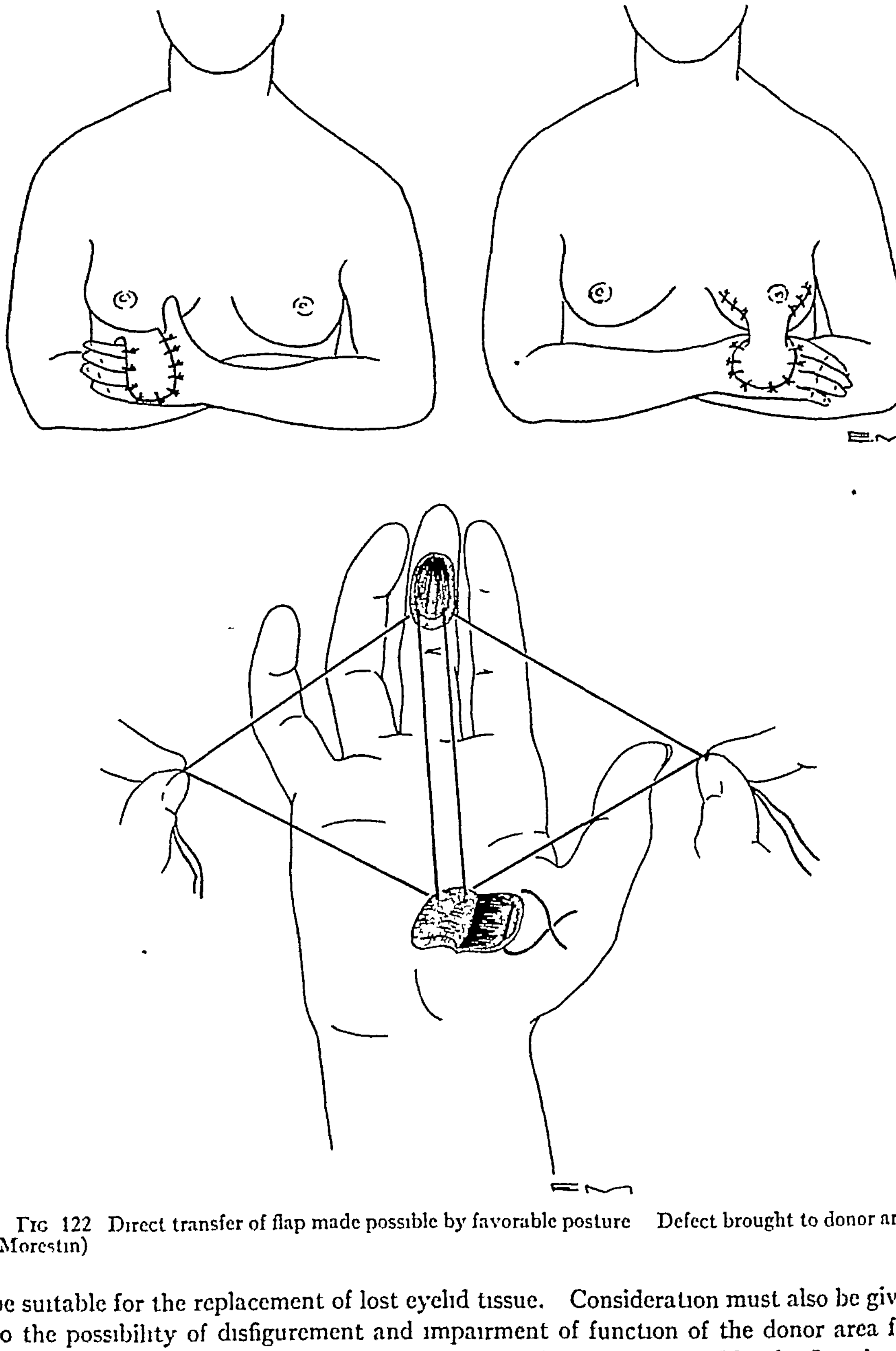


FIG 122 Direct transfer of flap made possible by favorable posture Defect brought to donor area (Morestin)

be suitable for the replacement of lost eyelid tissue. Consideration must also be given to the possibility of disfigurement and impairment of function of the donor area following the removal of the flap For this reason, whenever practicable, the flap should

be taken from an unexposed part of the body, preferably where the skin is lax enough to permit of secondary closure without the addition of new tissue.

Generally speaking, to replace losses of the upper part of the face and nose a forehead flap is the choice in the case of women, since it offers the best match, and since the secondary scar can be concealed by the coiffure. In men, however, the forehead scar cannot be hidden, and a temporal or postauricular flap is preferable. For defects of the lower half of the face in men a flap from the scalp pedicled on the temporal artery is most desirable as it furnishes hair to hide the scar in both donor and recipient areas. Similar losses in women are best replaced by a transverse cervical, vertical cervical, acromiopectoral, suprascapular, or bicipital flap Where the tissues in the vicinity cannot supply sufficient material to cover the loss, or where a secondary scar would be objectionable, the flap may be taken from the abdominal, oblique inguinal

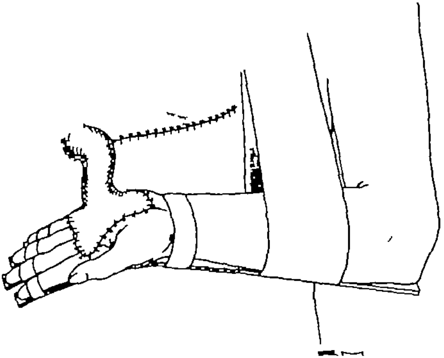


FIG 123 Direct transfer of flap made possible by favorable posture. Defect brought to donor area.

scapular, or thoracic region. To repair defects of the hand and forearm the skin of abdomen and lower back is particularly applicable, for the axilla, the scapular region, for the lower extremity, the opposite thigh, and for a loss of substance on the sole or heel, the opposite calf

Planning of Flap

Prior to the cutting of the flap, a general plan of repair is worked out and the number of stages calculated The first step is to ascertain the amount of tissue to be supplied. In unilateral losses this is determined by a comparison of the affected side with its fellow If the defect is bilateral, it will be found advisable to construct a cast, preferably by the aid of a photograph of the patient taken before the loss, and to build it up in wax or clay to the correct proportions. A pattern of the lost part is then fashioned either on the patient or on the model to serve as a guide in the cutting of the flap

This pattern is made of some pliable material, such as oiled silk, rubber tissue or chamois skin, and should be large enough to cover the area amply without tension (fig 118) From this pattern another one to be used as a model for the flap is reproduced in tin or lead, as this material has the advantage of retaining its molded form and can be sterilized with the instruments and used in the operating room For purposes of recording it is well to mark upon it the patient's name and the date To allow for shrinkage of the flap and possible failure of marginal union, this second pattern should be made ⅓ larger in all its dimensions than the first Obviously the pattern can be used only as a rough guide, inasmuch as the amount of shrinkage varies in different flaps, depending upon the rapidity of healing and the nature of the recipient

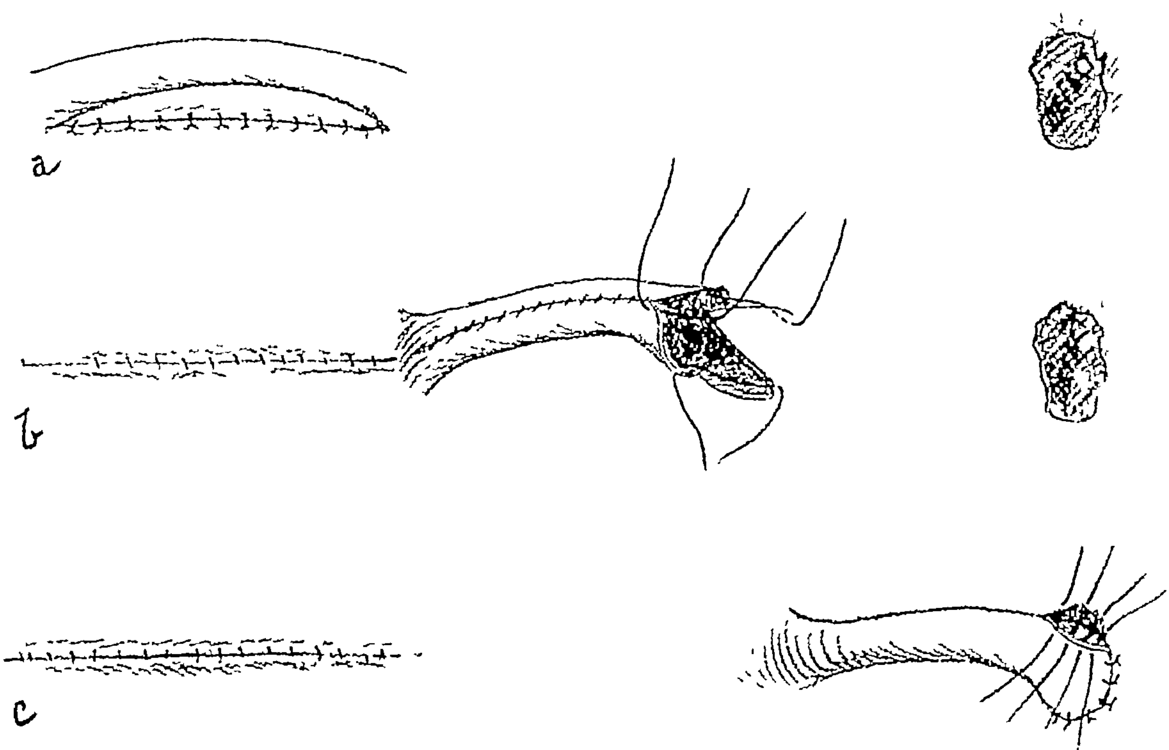


FIG 124 Indirect transfer of flap, when donor and recipient areas cannot be approximated directly Flap carried to destination by successive migration through one or more intermediate points of attachment *a*, bridge of tissue raised, its edges sutured longitudinally to form tubed flap, and underlying wound closed *b*, after vascularization, distal pedicle of flap severed and implanted into prepared site nearer defect *c*, other pedicle cut and sutured to pared margins of defect

site For instance, contraction will be comparatively slight when healing is rapid and when the surrounding tissues are of such a character as to resist displacement

Whenever possible, the flap should be planned in such a way that a main artery passes through its center, and should lie in the direction of the normal skin tension lines (figs 19–22) in order to permit easy closure of the donor site after it has been raised Figures 113–117 show the most desirable locations for the construction of flaps on the various parts of the body The pedicle is so fashioned that the flap can be swung into the defect without tension or torsion Gillies (127) designs the flap by visualizing the operation as completed and reversing the steps of the procedure For instance, in a defect on the posterior surface of the elbow to be covered by a flap taken from the abdomen (fig 118) he says, "The elbow is flexed and approximated to the side, bringing the defect as close as possible to the donor area The pattern is now fitted accurately

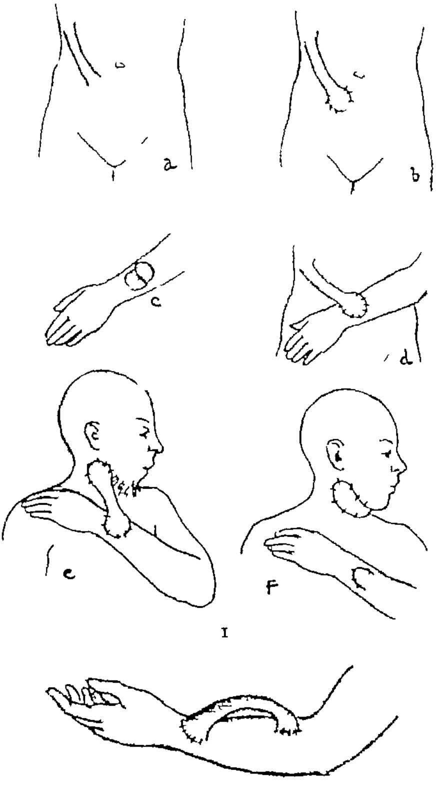


FIG 125 Indirect transfer of flaps, when donor and recipient areas cannot be approximated directly Flap carried to destination by means of intermediate carrier *Ia*, tubed flap raised on abdomen. *b* distal pedicle cut and resutured into original site, to enhance nutrition of flap *c* flap raised on wrist, to provide bed for abdominal flap *d* distal pedicle of abdominal flap sutured to prepared area on wrist, *e*, proximal pedicle cut. Flap on carrier brought to neck and sutured in place. *f* neck scar excised. Flap separated from carrier and sutured into balance of defect. Wrist wound closed (Webster) *II* method of implanting tubed flap for delayed reconstruction (Gillies)

to the defect The assistant holds the lateral edge carefully in position while the medial edge is turned over onto the abdominal skin and held by the surgeon in the position which it naturally takes so as to leave the intervening portion comfortably slack. The lateral edge of the pattern is then released and the arm moved away from the side while the surgeon smooths the remainder of the pattern over the abdomen The skin outlined by the pattern is marked by scratching, and dissected up to form a flap, the attached side of the flap on the abdomen corresponding to the edge of the pattern first shifted to the body. . . . After two or three weeks the attached end of the flap is divided and sutured into position on the arm The line of division can be readily marked out by placing the pattern in position over it" Gillies states that when this method is employed, the flap will fit into its new bed accurately without having to be pulled into place by overstretching

In the case of an indirect transfer, the intermediate points of attachment must be so planned that the flap can be brought into the defect in the least number of stages If an intermediate carrier, such as the wrist, is to be employed, the transfer must be calculated in such a way that the movable part may subsequently be approximated to the defect in the most comfortable position

The proportions of the flap, whether it is to be transferred directly or "delayed," will vary with the blood supply and the number of pedicles When the flap cannot be made to carry a main artery and is to be transferred directly, the width of the pedicle at its narrowest part should equal at least $\frac{1}{2}$ the greatest width of the flap and $\frac{1}{3}$ its greatest length If broader than this, it will interfere with rotation, and if narrower, it will be unable to furnish adequate nutrition If the flap is to be "delayed," however, the pedicle may be made somewhat narrower and the flap longer German, Finesilver, and Davis (123) have shown that when a flap is "delayed," the blood vessels enlarge and arrange themselves longitudinally When the pedicle incorporates a main artery, it need be wide enough only to carry the artery, and the flap may be as long as the blood vessel In the head, flaps may be so planned as to incorporate the temporal artery in front of the ear, the transverse facial extending from the temporomandibular articulation to the ala nasi, the external maxillary extending from the anterior border of the masseter to the inner canthus, the occipital, or the frontal and supra-orbital extending from the inner canthus over the forehead Figure 113 is self-explanatory.

Operative Considerations

As in the case of any operation, a preliminary examination is made to ascertain the patient's physical condition and potential healing powers (Chapter VIII) No flap operation should be attempted until all signs of infection and acute active pathologic processes have been eliminated If the flap is to replace a loss of tissue arising from malignancy, a sufficient interval must have elapsed to insure against recurrence. The nature of the operative procedure and the probable number of stages nec are explained to the patient and a choice given him between a prosthesis and a reconstruction In the case of individuals of advanced age or in poor health, c there is a likelihood of recurrence of a malignant process, a prosthesis is the best solution (Chapter XX)

Anesthesia Flap operations may be performed under local or general The former is preferable, since it does not incur postanesthetic vomiting,

concomitant danger of traction on the pedicle. It is best obtained by nerve block or field block. Infiltration into the part destined to form the flap should be avoided, as the solution has a tendency to lower the resistance of the tissues and predisposes to postoperative oozing When a local anesthetic is contraindicated, as in the case of children, basal narcosis supplemented by gas-oxygen or ether is employed. For details of technic the reader is referred to Chapter VII.

Preparation of Recipient Area. The defect is prepared just before the implantation of the flap, the technic differing in no essential from that used in the case of a graft (p 118)

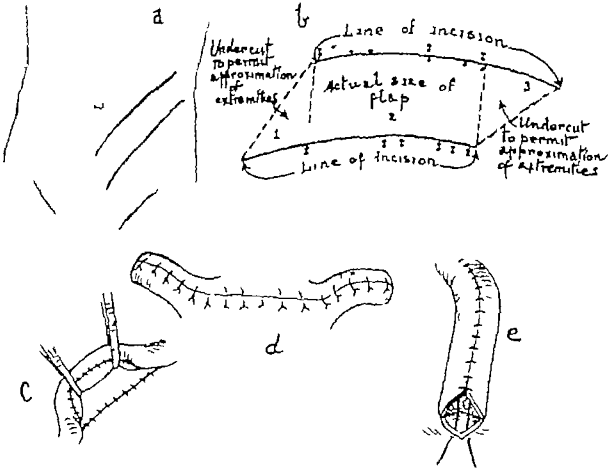


FIG. 126 Formation of tubed flap *a*, incisions outlining flap. *b*, diagram, showing staggering of ends, *to facilitate approximation of extremities of tube.* Triangles 1 and 3 completely undercut, so that all wound edges may be united without tension Single dots indicate points of approximation for closure of tube. Double dots indicate points of approximation for closure of underlying wound (Davis) *c* tube completed and donor wound closed. *d* diagram, showing line of approximation to eliminate all raw surfaces. *e* another method of closing extremity of tube (Gillies)

Cutting of Flap. The donor site is prepared and draped in the customary manner (p 123) A previously prepared metal pattern is placed on the skin and outlined in methylene blue in a hypodermic syringe, the needle acting as a pen. A series of dots, 1 to 2 cm. apart, are then pricked out at exactly corresponding sites along both sides of each outlining incision, to act as landmarks for placing the sutures (fig 126 b) Without such a guide the distortion of the tissues occasioned by the local anesthetic is apt to create difficulty in bringing the margins into their proper relationships. The

flap is cut around by means of an arched incision, since a flap with a curved outline is less likely to slough and is better able to adapt itself to defects of any shape The depth of the incision will depend upon the size and thickness of the desired flap If the flap is to replace a shallow defect, the separation is made just below the subcutaneous fatty layer Under no circumstances should the plane of separation be made at a higher level since the cutaneous blood vessels necessary for the nutrition of the flap lie in the subcutaneous fat close to the superficial layer of the deep fascia Any excess fat which remains after the flap is established in its new location can be removed at a second operation by opening one portion of the flap and excising it To replace deep defects the separation is made between the superficial and deep fascia or between the deep fascia and the muscle Muscle tissue itself should not be incorporated in the flap when this can be avoided, since a muscle deprived of its nerve supply is soon converted into fibrous tissue which may impair the viability of the flap In the face, however, muscle tissue must of necessity be included, as in this locality the muscles

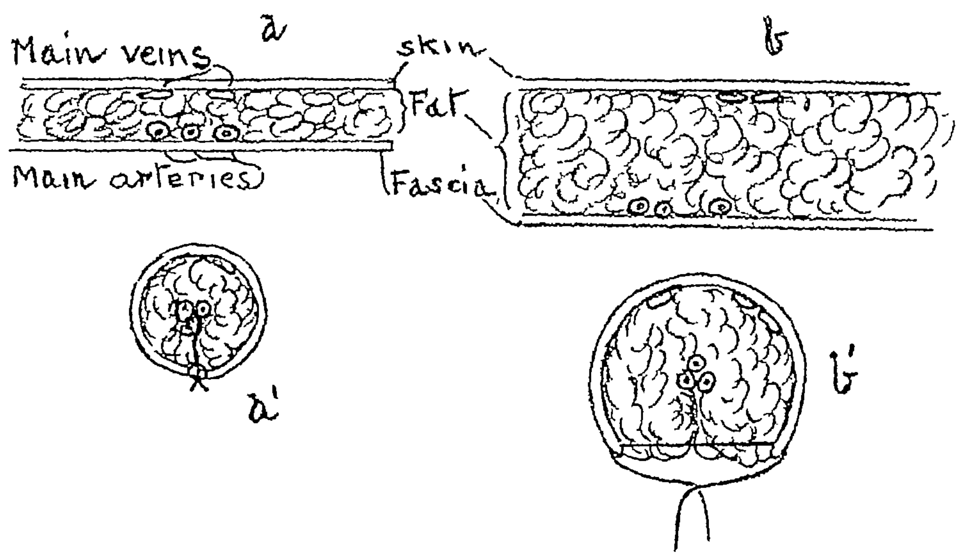


FIG 127 Sectional views of flaps taken from thin and obese individuals *a–b*, flaps before tubing, showing difference in amount of adipose tissue. *a′–b′*, flaps tubed, *b′* requires fat excision, to make possible skin closure without strangulation of vessels (Webster)

are inserted directly into the skin The flap should be raised with the utmost gentleness to obviate traumatization of the margins or the base, as this stimulates scar tissue formation which interferes with the blood supply of the flap, reduces its pliability, and may lead to sloughing Hemostasis must be absolute It is preferable, for reasons already given (p 121), to check bleeding by the application of hot packs and by crushing the ends of the blood vessels, rather than by ligation As in the case of grafts, hematomata interfere with the apposition of the raw surfaces, and even should the flap survive, the cicatricial changes in the blood-clot will make it less pliable

Implantation of Flap. The flap is swung and fitted into the revivified defect without stretching, twisting, or blanching of the pedicle Any buckling is attended to after vascularization has taken place No attempt should be made at the time of implantation to improve upon the jointure by notching, as this may impair the blood supply An intimate contact of the flap with the underlying raw surface should be provided, so that new capillary loops from the base may rapidly penetrate The flap

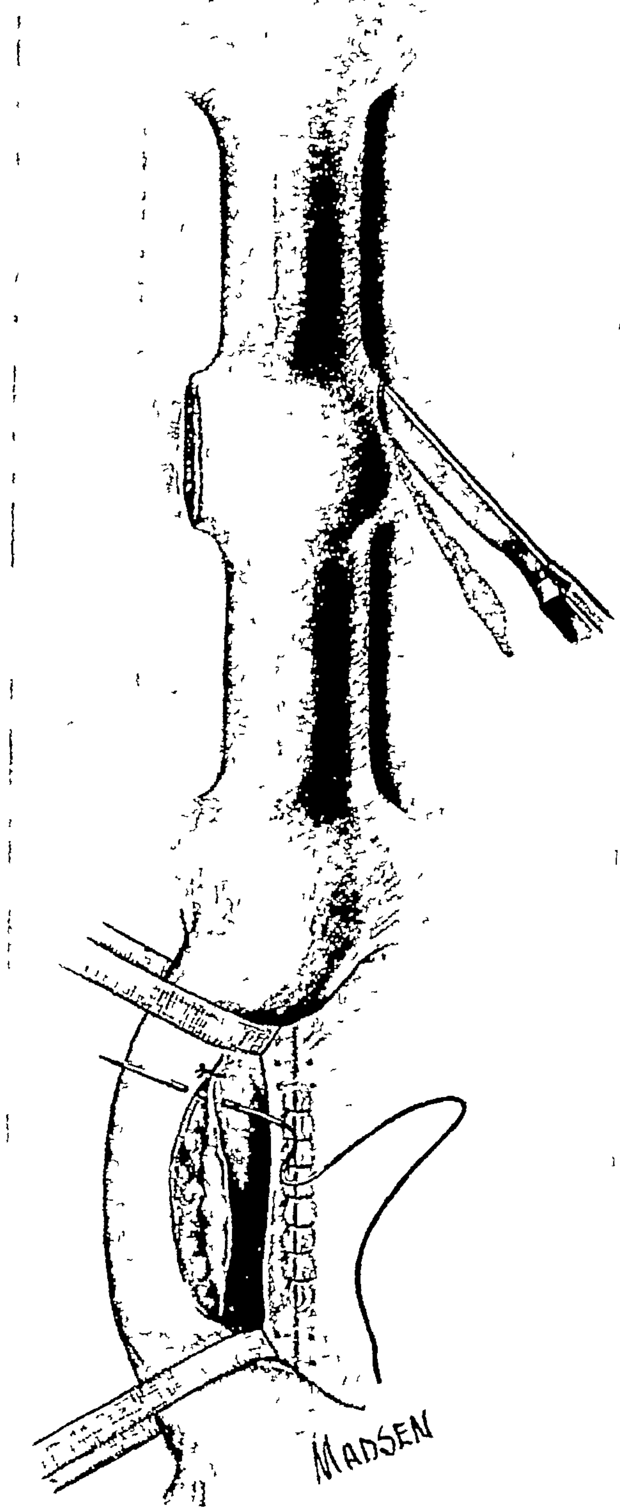
is carefully and precisely stitched into the defect with interrupted sutures of horsehair or fine silk on a half-curved atraumatic needle. On the face a subcuticular suture is preferable In any case the sutures should serve merely to hold the flap to the defect without pulling the parts together Tension must be avoided at all costs. Should blanching occur at any point, the offending suture should be removed at once, otherwise, sloughing is likely to ensue While interrupted sutures require more time, they are safer, because if one suture loosens or must be removed it does not endanger the entire suture line Another advantage is that the spaces between the sutures permit of the escape of secretions.

Closure of Donor Area. The wound left in the donor area by the raising of the flap should be closed immediately to prevent infection which might spread to the flap itself If the laxity of the part permits, the margins are undermined for a distance sufficient to allow drawing together of the edges without tension. A small drainage tube is inserted and left in place for 24 hours to prevent the retention of secretions Closure

FIG. 128. Removal of longitudinal scar and excess fat from tubed flap prior to implantation of pedicle. (Gillies)

is effected in layers. The fascia and subcutaneous tissues are approximated with interrupted sutures of silk or fine catgut, and the skin with interrupted on-end sutures of silk or horsehair, the latter sutures being made to pass through the previously marked points. If there is difficulty in approximating the margins, Webster (355) suggests that "longitudinal incisions. be made through the superficial layer of the deep fascia on either side well away from the cut edges, so that the continuity of this strong sheet of fascia may be broken to permit easier closure This procedure is to be preferred to another that is frequently advised, namely, the relaxing incisions made through the skin and subcutaneous tissue By the hidden incisions here advised, no further wounds are made which have to be left open, no resultant scar deformity is added, and closure is facilitated."

If direct approximation can be obtained only at the expense of extensive undermining it is better to cover the area with a razor graft, since undercutting severs the arterial branches with their accompanying veins and endangers the blood supply of the flap The use of a razor graft offers some difficulty, however, since the pressure dressing that must necessarily be applied may interfere with the circulation in the



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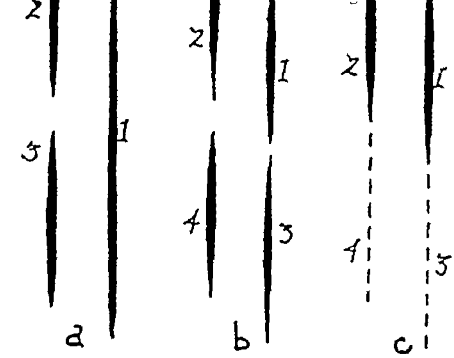
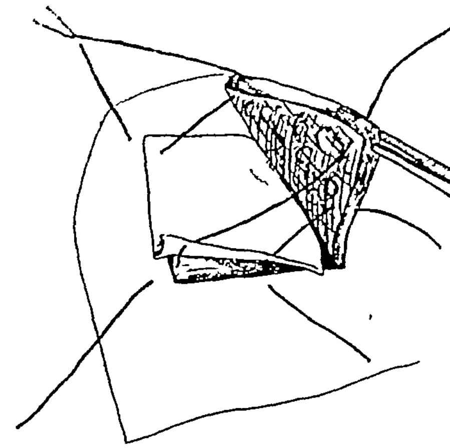


II



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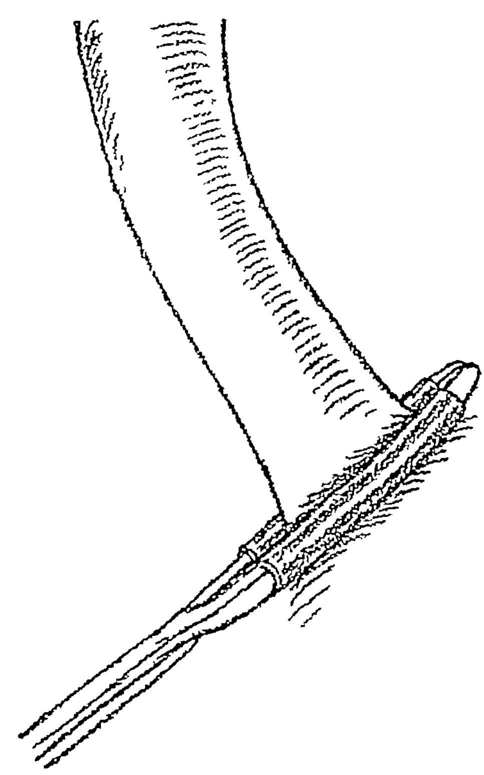


IV

FIG 129. Methods of enhancing nutrition of flap *I*, by increasing number of pedicles Ribbon of tissue raised and tubed, with several intervening uncut portions serving as pedicles, serially cut at 2- or 3-week intervals, as circulation of flap becomes established *II*, incisions for construction of multipedicled flap *a*, for formation of 3-pedicled tube (Webster) *b*, plan for formation of 4-pedicled tube. *c*, tubing in stages. Solid lines *1* and *2* represent portion of flap raised and tubed at first stage After vascularization, tube gradually extended along dotted lines *3* and *4* *III*, piece of rubber tissue, cut to pattern, interposed between flap and bed Flap sutured back in place and thus forced to receive its nutrition from pedicle alone (Croft) *IV*, pedicle of flap intermittently compressed, to force flap to receive its entire nutrition from other pedicle For details, see text

overlying pedicle When the condition of the patient does not permit of immediate closure of the wound, a sterile dressing is applied and approximation or grafting is delayed until he is better able to withstand the procedure.

Dressing A protective dressing is built up around the flap in such a manner as to permit of frequent inspection and at the same time relieve the pedicle of all pressure, since any constriction may partially cut off the circulation to the flap and lead to sloughing

Immobilization. The parts are then immobilized to prevent displacement of the flap or tension on the pedicle Immobilization is secured by means of splints, elastoplast, adhesive plaster, or plaster of Paris, depending upon the location The latter material has largely supplanted the complicated immobilization apparatus formerly resorted to The cast may be split to make it removable and held in place with straps When such a cast is contemplated the patient may be inured to its use by being required to wear it for several days prior to operation In a limb-to-limb approxima-

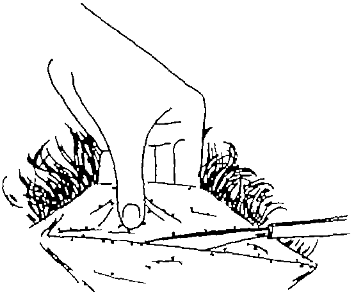


FIG. 130 Depilation of hair bearing flap Skin elevated, and layer containing hair follicles excised Skin sutured back in place. Ten days later flap containing depilated skin raised

tion it is advisable to apply the plaster dressings to each limb before operation and to join the two by additional plaster after the flap is in place. The methods of immobilizing special parts will be discussed in the appropriate sections If the immobilization causes discomfort, the patient should be helped through the period by the prescription of appropriate sedatives.

After-Care The flap is inspected at frequent intervals so that complications may be attended to as they arise and possible disaster forestalled. Immediately after its implantation the flap is pale and insensitive and its temperature is less than that of the surrounding parts. In the course of 2 or 3 days it becomes congested and the local temperature rises. As the circulation readjusts itself the flap gradually assumes the appearance of the surrounding parts.

Any tendency to cyanosis indicates an interference with the venous outlet. This can frequently be relieved by gentle efferent massage, the application of hot compresses, incisions into the flap, or the removal of an offending suture If the flap remains

The skin between the two incisions is then undercut in the plane below the superficial fascia, and the flat ribbon of tissue thus separated is elevated by traction exerted on a strip of gauze passed beneath it Hemorrhage is controlled in the manner already described (p 60) Hemostasis must be absolute, for if blood is allowed to accumulate, it will press upon the blood vessels of the flap after tubing and may lead to necrosis Any excess fat along the borders of the flap is excised to avoid tension on the skin margins and possible necrosis when the tube is formed (fig 127), but care must be taken to leave enough to nourish the skin

(2) **Suturing of Long Margins.** After the bridge of tissue has been elevated by traction exerted on a loop of gauze passed beneath it, the skin edges are rolled in and

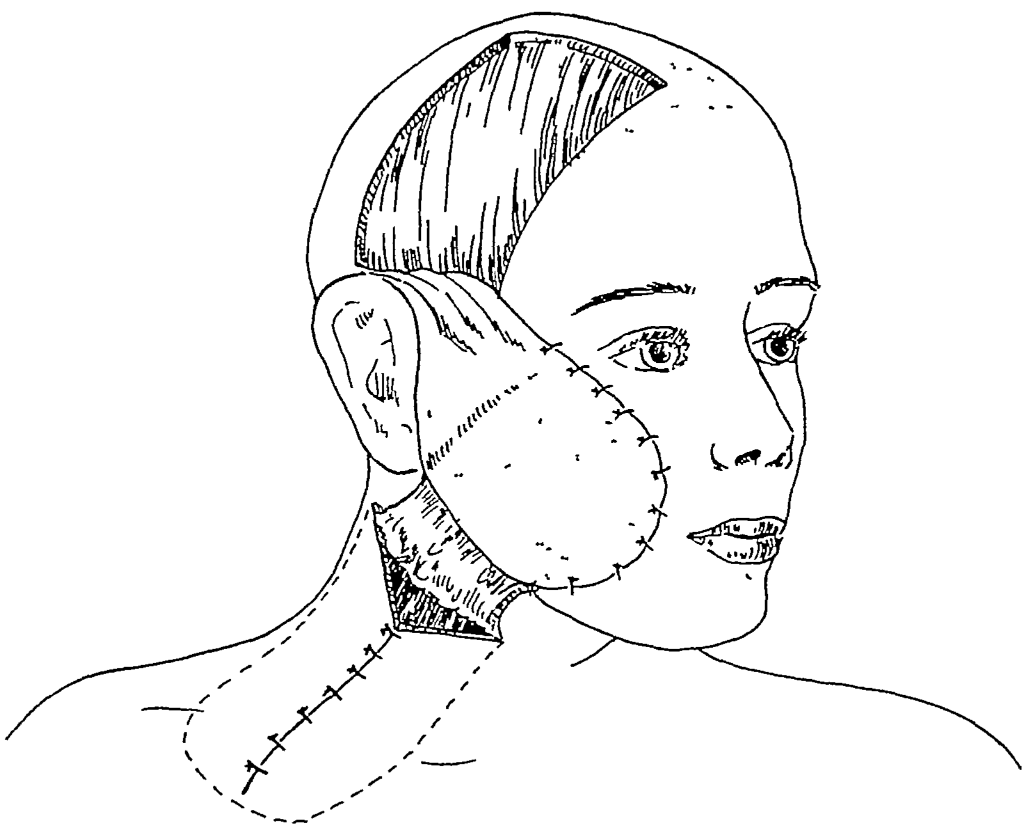


FIG 132 Illustration of use of contiguous flaps to supply cover and lining in repair of full thickness cheek loss

the margins are caught at their central portion by a silk suture, the ends of which are left long Three or four similar sutures are then passed at points equidistant from the center Pulling on these traction sutures will bring the margins into view On-end sutures of horsehair or silk on an atraumatic needle are now passed along the previously marked points to complete the tube, small bites being taken to avoid strangulation When all of the sutures have been passed, they are tied, and any excess fat bulging in between is carefully cut away Tension is to be avoided at all costs, otherwise, the subsequent swelling of the tube may increase the pressure to such an extent as to result in an arrested blood supply and necrosis of the flap If a suture causes blanching, it is immediately taken out Several rubber band drains are introduced between the sutures and removed in 48 hours

(3) **Closure of Donor Area.** When the tube is completed, it is held aside by means

of gauze loops, and the margins of the defect are coapted in the manner already described (p 223) (fig 126c) After the margins of the tube and of the underlying wound have been approximated, it will be found that two apposing uncovered triangles with their apices pointing medially remain at the junction of each pedicle with the surface from which the flap was raised, one on the tube and the other on the adjacent donor surface. These areas must be closed, otherwise, the raw surface will expose the flap to infection, and the scar contraction occasioned in the process of healing will shorten the tube and render it less pliable. Closure is accomplished by visualizing the suture line on the flap and that on the wound as one continuous line and suturing them accordingly (fig 126d)

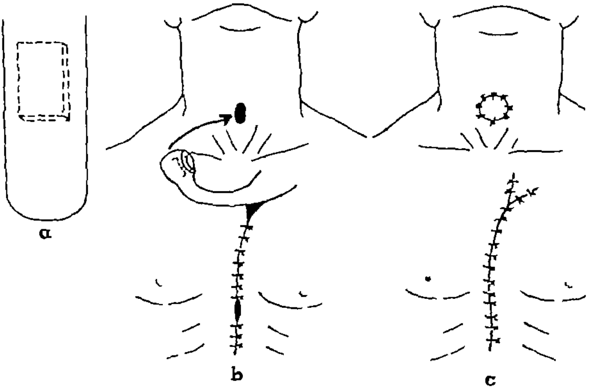


FIG. 133. Illustration of use of turned-over flap to supply cover and lining in repair of tracheal fistula. *a*, fragment of costal cartilage implanted beneath skin flap in lower sternal region. Lining supplied by folding distal end of flap on itself *b* at second stage, tube formed above lined skin-cartilage flap, at third stage, tube united with doubled-over flap *c* flap sutured to pared margins of defect. After vascularization, pedicle divided and fitted into remaining margins of defect. Stump returned to donor site. (Killian)

Gillies (129) approximates the triangles in a tubed flap raised from the abdomen in the following manner "The apices of the two triangles are approximated by a special suture (fig 126e) The needle is passed through the skin of one side of the abdominal edge, emerging in the subcuticular area It is continued as a subcuticular stitch first down one side and then up the other of the apex of the tubed pedicle triangle. Finally, it emerges opposite its entrance at the apex of the abdominal triangle When tied the two triangles are accurately approximated"

(4) **Dressing** Five or six layers of xeroform gauze with their ends slit longitudinally are laid over the suture line on the donor area, their ends straddling the pedicles. The uppermost layer of gauze is wrapped around the tube and several layers of dry gauze are inserted beneath it to support the tube from below and prevent a pull on the

pedicles, and are held in place by means of adhesive tape Several folded gauze compresses are then built up around the pedicles to prevent their constriction by the overlying dressing. Finally, the whole is overlaid with a large cotton pad covered by a layer of gauze and held in place with adhesive tape The dressing should be so arranged as to permit frequent inspection of the flap

The sutures are removed on the seventh or eighth day at which time the patient may be discharged from the hospital until he is ready for the next stage

Transfer of Flap to Recipient Area

The second stage consists in cutting the distal pedicle and reimplanting it This may be done as soon as collateral circulation has been established in the flap, a process

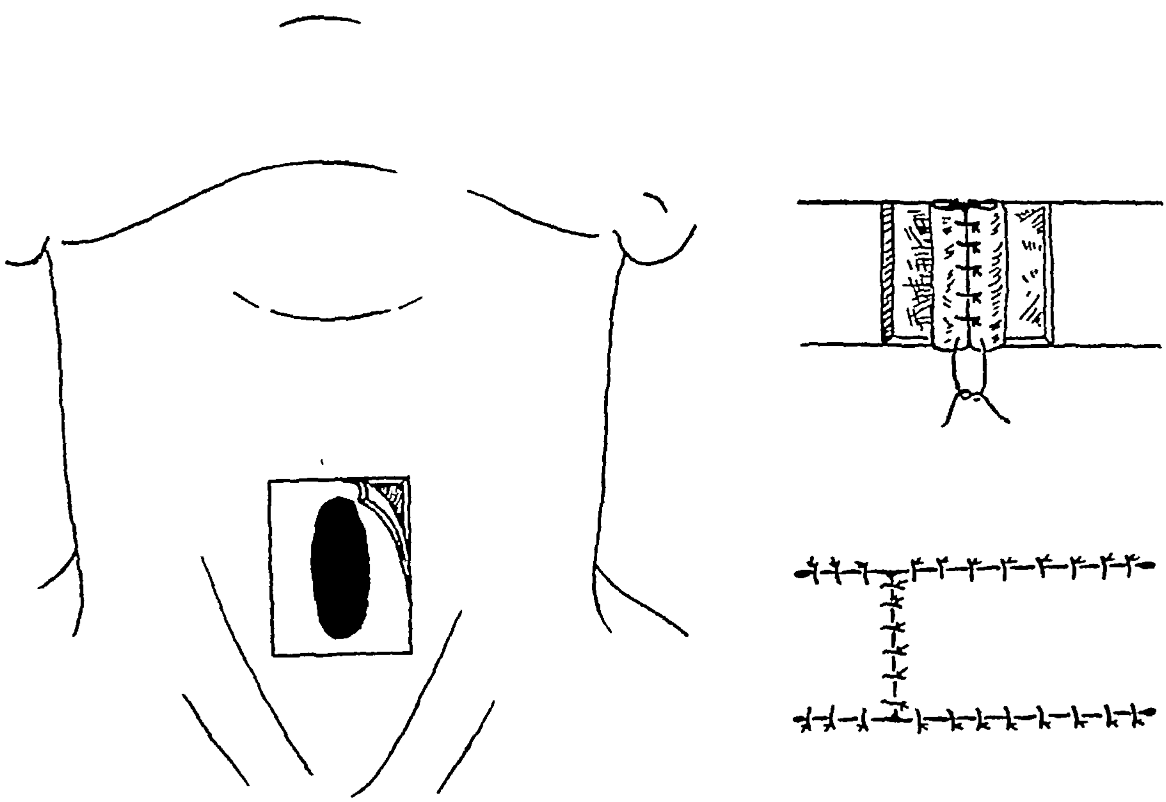


FIG 134 Illustration of use of contiguous skin for lining and of advancement flap for cover in repair of tracheal fistula Skin flaps, pedicled on wound margins, turned skin side in, hinge-fashion, and united to each other, to form lining Skin on either side of defect undermined, advanced over raw area, and united in midline, to supply cover (Kirschner)

which usually requires three weeks After the viability of the flap has been determined in the manner already described the pedicle is cut by a V-shaped incision (fig 124b), care being taken to incorporate as little untubed tissue as possible, since this tissue is devoid of an established longitudinal blood supply and is likely to succumb if transplanted

The area into which the severed end is to be implanted will depend upon the location of the area to be repaired (1) If the recipient site is near enough to permit of direct implantation of the flap, the bed is prepared just prior to severance of the pedicle as previously explained. The tube is opened for not more than half its length by the excision of the longitudinal linear scar. It is then unrolled and sutured accurately

into the defect without tension or kinking of the pedicle. (2) If the recipient site is too distant to permit of direct implantation, the flap may be transferred indirectly in one of two ways (a) by successive migration, whereby the severed end is inserted into a bed situated nearer the defect (p 209) (fig 124) or (b) by means of an intermediate carrier, such as the wrist or ankle (fig 125) In order to prepare the carrier for the reception of the flap a V-shaped incision is made in a location that will permit of the subsequent transfer of the flap to the area to be repaired without any kinking of the pedicle and with a minimum of discomfort to the patient (fig 125 I, c) The triangular flap outlined by this incision is sutured to the cut end of the pedicle in such a manner as to leave no raw surface exposed. To obtain close approximation between the pedicle and the base, several mattress-sutures are employed. When vascularization has taken place through the carrier, a process which usually requires 3 weeks, the donor pedicle is detached, and the flap brought to the defect on the carrier and sutured in place, the movable member furnishing the necessary blood supply The extremity is fixed by means of bandages in such a position that the pedicle will remain unkinked and without tension until healing takes place

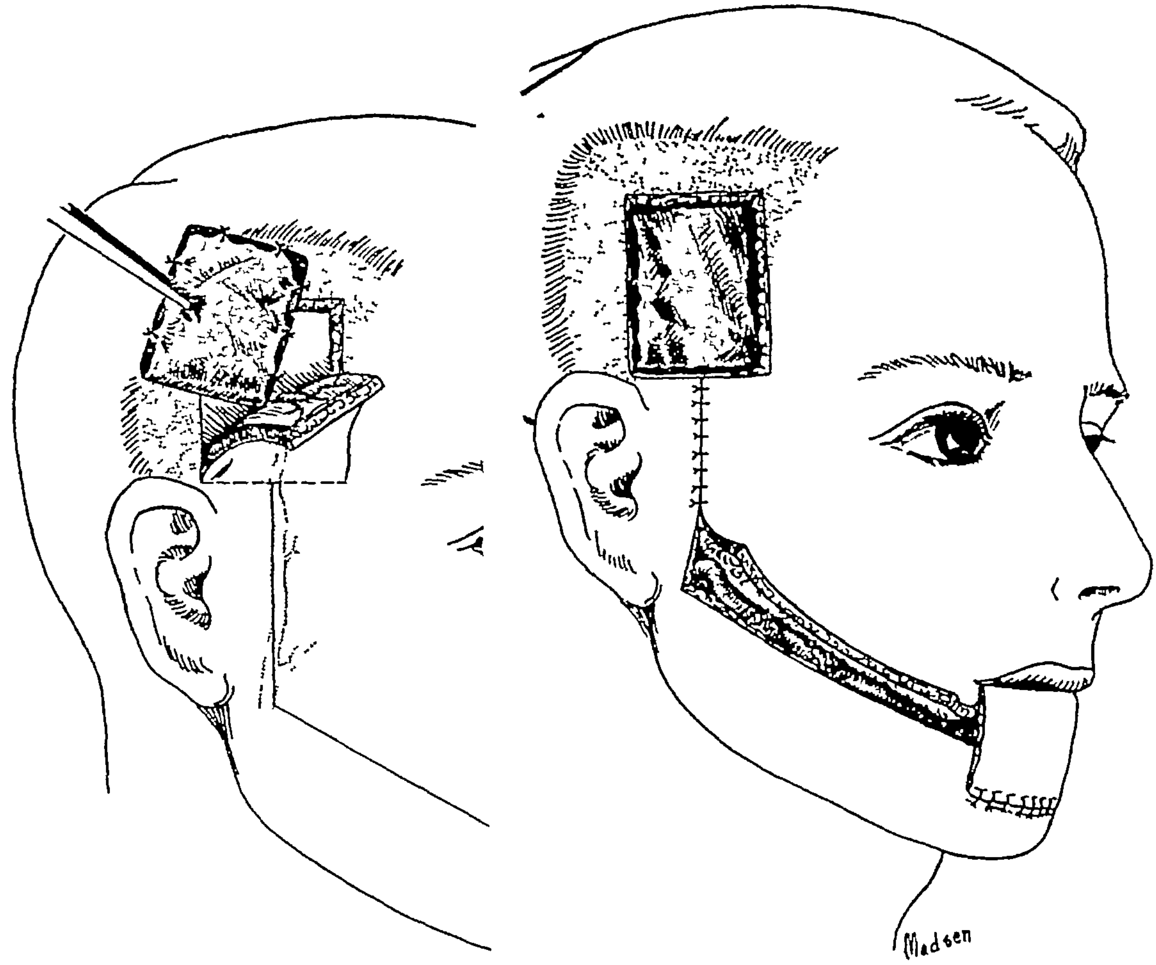
Separation of Flap from Donor Site

The third stage comprises the freeing of the remaining pedicle from its host When the blood supply from the bed is sufficient to nourish the flap, that is, in about 3 weeks, the pedicle still attached to the original donor site is severed The remainder of the flap is opened up and unrolled throughout its entire extent, as described above, and fitted into the bed. In excising the scar tissue and in unrolling the tube, care must be taken not to injure the newly formed collateral blood vessels If an intermediate carrier was used the V shaped flap, previously raised, is trimmed of scar tissue, and resutured back into place

Island Artery Flaps

By the term "island artery flap is meant one which has a pedicle composed merely of an artery with its accompanying veins, nerves, and lymphatics. It was first described by Monks (245) who used a flap of forehead skin pedicled on the temporal artery to reconstruct an upper lid This type of flap provides an ideal blood supply and an efficient venous outlet and its value is further enhanced by the fact that it permits of the completion of the procedure in a single stage But great care is demanded in the dissection of such a flap if necrosis is to be prevented.

Technic After the course of the artery has been determined by palpation, an incision just deep enough to expose the vessel is made over the whole length of the part intended for the pedicle The vessels are then carefully dissected free from the surrounding tissues by a scalpel passed to the right and left of them until they are left surrounded by a sheath of cellular tissue only A flap with the freed blood vessel as its pedicle is then outlined to pattern, raised, and placed in the defect in one of two ways. The pedicle may be buried in a newly made incision so planned as to avoid torsion on the pedicle (169), or the flap may be drawn into the defect through a subcutaneous tunnel, the pedicle being left buried in this tunnel after the flap is fixed in place (figs 135–136)



a b

FIG 135 Island artery flap to supply lining and cover for repair of full thickness lip and chin defect *a*, under surface of proposed flap lined with razor graft on stent mold Vertical line indicates incision to expose artery, oblique line, incision for burial of arterial pedicle *b*, lined scalp flap sutured into defect Temporal artery embedded in subcutaneous tissue. (Horsley)

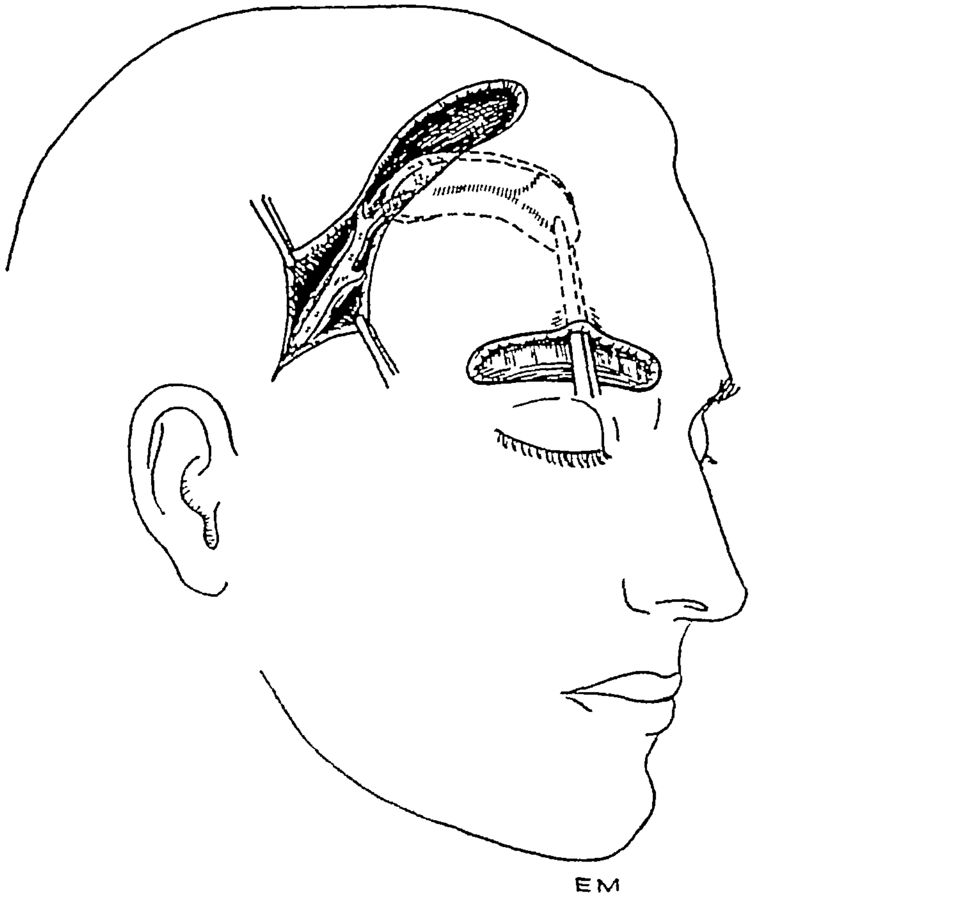


FIG 136 Use of island artery flap to replace missing eyebrow Flap carrying row of hair and pedicled on temporal artery drawn through subcutaneous tunnel (Monks)

Bridge Flaps

A bridge flap is a double pedicled untubed flap, the most common example of which is a *bridge* of skin raised on the abdomen, chest, back, or thigh for the repair of a defect on the hand or arm Two incisions are made in the donor area to the depth of the fascia and the bridge of tissue thus outlined is raised by undermining After hemorrhage has been controlled, the recipient area is passed beneath the flap as one would insert the hand into a muff (fig 137) The parts are secured by suturing the flap into the defect and are immobilized until vascularization takes place, at which time the pedicles are cut, the margins of the defect trimmed, and the donor wound closed. Another common example of the bridge flap is a forehead flap pedicled on

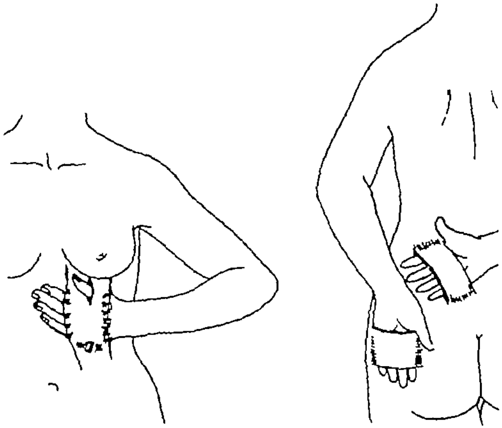


Fig 137 Use of bridge flaps for repair of defect in palmar and dorsal surface of hand

the temporal arteries and brought down over the face in the form of a visor In order to diminish the extent of raw surface exposed, that part of the flap not to be used is tubed. The advantages of such a flap are outlined on page 1267

Special Flaps

Flaps may be obtained either from the tissue in the vicinity of the defect or from distant parts of the body, the choice being governed by the nature and location of the defect and by the condition of the surrounding tissues.

Flaps from Vicinity of Defect

(1) **Contiguous Flaps (French Flaps)** When a defect due to a loss of tissue cannot be closed by direct approximation of its margins, it may yet be possible to cover it without the addition of new tissue by undermining and making incisions in various

directions, so that the surrounding parts may be advanced, rotated, or transposed over it. Although the principle governing this method originated in antiquity, its modern usage dates from 1830 when Larrey (198) reintroduced it in Europe where it immediately gained popularity in the hands of such famous surgeons as Delpech, Dupuytren, Lisfranc, and Serre and became known as the "French flap." While this method has the advantage of simplicity, it is applicable only for minor defects and

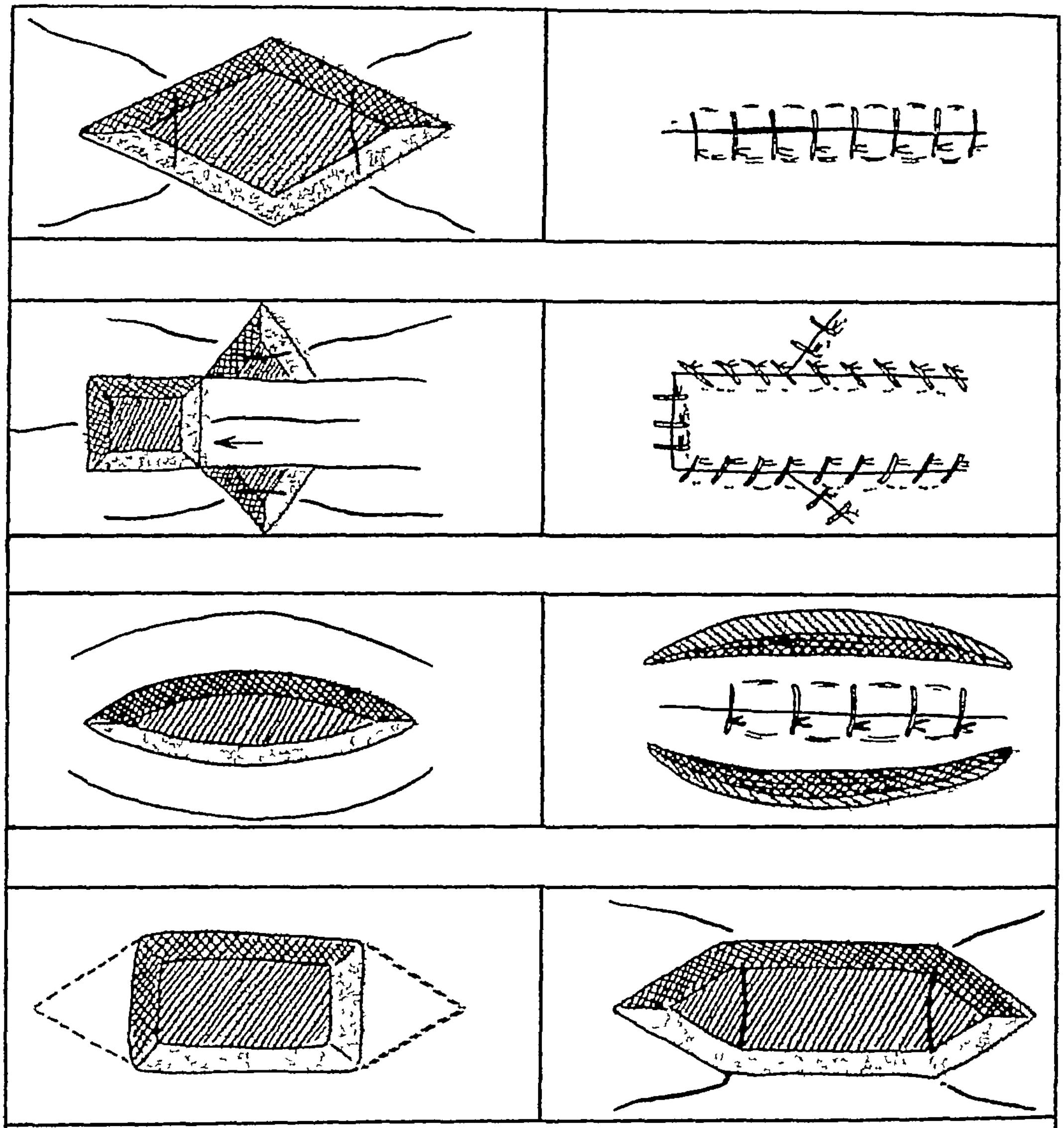


Fig 138 Various types of advancement flaps to close surface defects Tissues contiguous to defect undermined and advanced without altering plane of pedicle

those in which the surrounding tissues are sound and sufficiently lax to permit of manipulation In the case of large defects it would cause too great a distortion of the surrounding parts to warrant its use Regardless of the size of the defect, however, it is best avoided about the eyelids and lips, as in these areas even slight displacement of the tissues is disfiguring It finds its greatest application in the treatment of defects on the neck, breast, and abdomen where the tissues are naturally lax

(a) *Advancement Flaps* This type of flap contemplates mobilization of the wound

margins by undermining and advancing the tissues to cover the defect without altering the plane of the pedicles. The use of this method is limited by the extent to which the skin may be stretched without loss of vitality and is therefore applicable only for the repair of small defects such as those arising from the excision of a nevus or a linear cicatrix (p 1369) The defect is pared in such a manner as to transform an irregular wound into a geometric figure like an oval, triangle or rectangle The

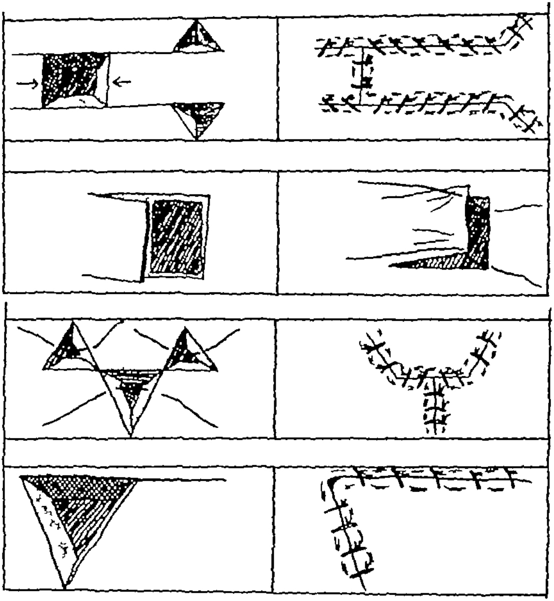


FIG 139 Various types of advancement flaps (cont.) Buckling relieved by removal of Burow s triangles

margins are undermined and the tissues advanced over the area to be covered and approximated (figs 138–140) If the tension after undermining is too great to permit of easy closure, it may be relieved by various additional incisions in the surrounding skin For instance length may be gained at the expense of breadth and vice versa if a V shaped defect is sutured as a Y or a Y shaped defect as a V (fig 140) Obviously, it would be impossible to mention all the various methods which have been

utilized in closing defects of different shapes Those which have become standardized are illustrated in Figures 138–141 and may be modified to meet almost any need.

In *oval-shaped defects* the margins, after being undermined for a distance sufficient to obtain the necessary relaxation, are brought into apposition by traction exerted on hooks placed in both ends of the wound If enough relaxation cannot be obtained in this manner, parallel incisions on one or both sides of the wound are made to further

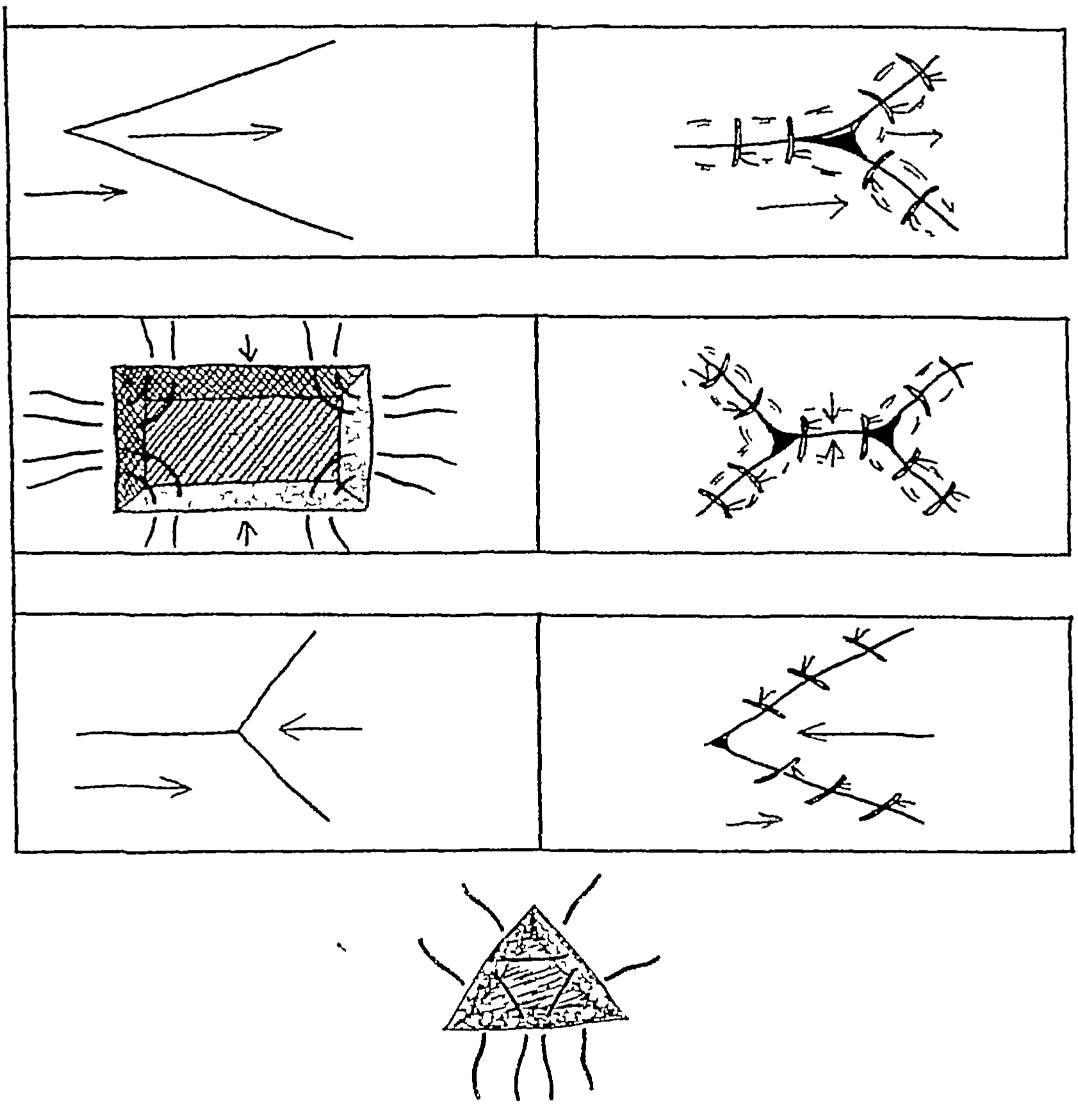


FIG 140 V–Y advancement flaps From above down V-shaped wound closed in form of Y, to obtain length at expense of width Rectangular wound closed in form of double Y Y-shaped wound closed in form of V, to obtain width at expense of length Triangular wound closed in form of Y, to relieve tension, deep suture passed through center of two sides, to emerge through center of third side

relieve the strain A suture is passed through the center of the wound, dividing it in halves, a second suture is placed in the center of each half, thereby subdividing the wound into quarters This procedure is repeated until the entire wound has been closed

Small *triangular defects* are closed by suturing them in the form of a Y This is accomplished by passing a series of interrupted sutures from the angles of the wound toward the center. To relieve skin tension a deep suture is passed through the center

of two sides, the ends being made to emerge through the center of the third side where they are tied (fig 140) To close large triangular defects the method suggested by

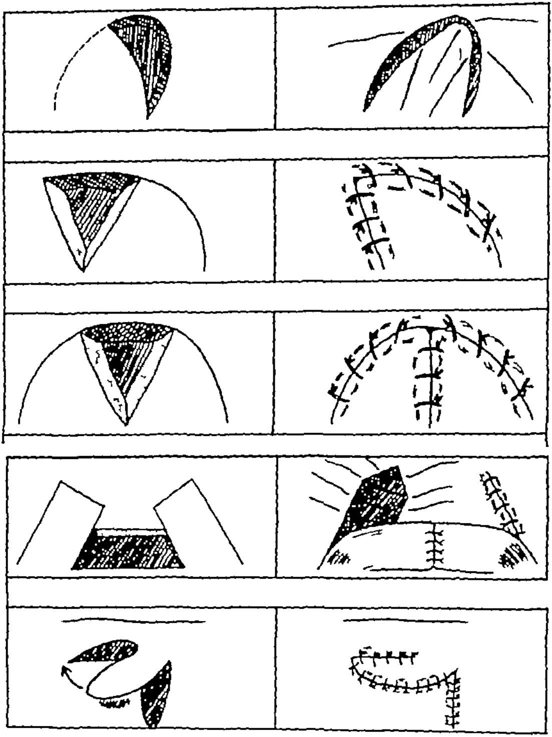


FIG 141 Various types of swinging advancement flaps to cover surface defects. One margin of defect constitutes one side of flap Pedicle forms part of reconstructed field when flap is rotated into defect Need of severing pedicle thus eliminated. Upper figures illustrate use of method for closure of triangular defects, base of triangle prolonged by uni or bilateral arched incisions through adjacent tissue. Flap or flaps mobilized and swung over defect. Lower figures show use of method for closure of quadrilateral defects

Jaesche (178) may be employed The base of the triangle is prolonged by straight or curved uni- or bilateral incisions through the adjacent tissue. The flap or flaps

thus outlined are mobilized by undermining, and the margins are approximated over the defect The resultant buckling at the ends of the relaxation incision may be overcome by the removal of two triangles, each ¼ the width of the original defect (42). Figure 139 is self-explanatory The objection to this procedure is the fact that it sacrifices sound tissue and creates additional scarring

The closure of *rectangular defects* is facilitated if they are made to assume an oval shape by the removal of triangular sections of tissue at each end (fig 138) Another

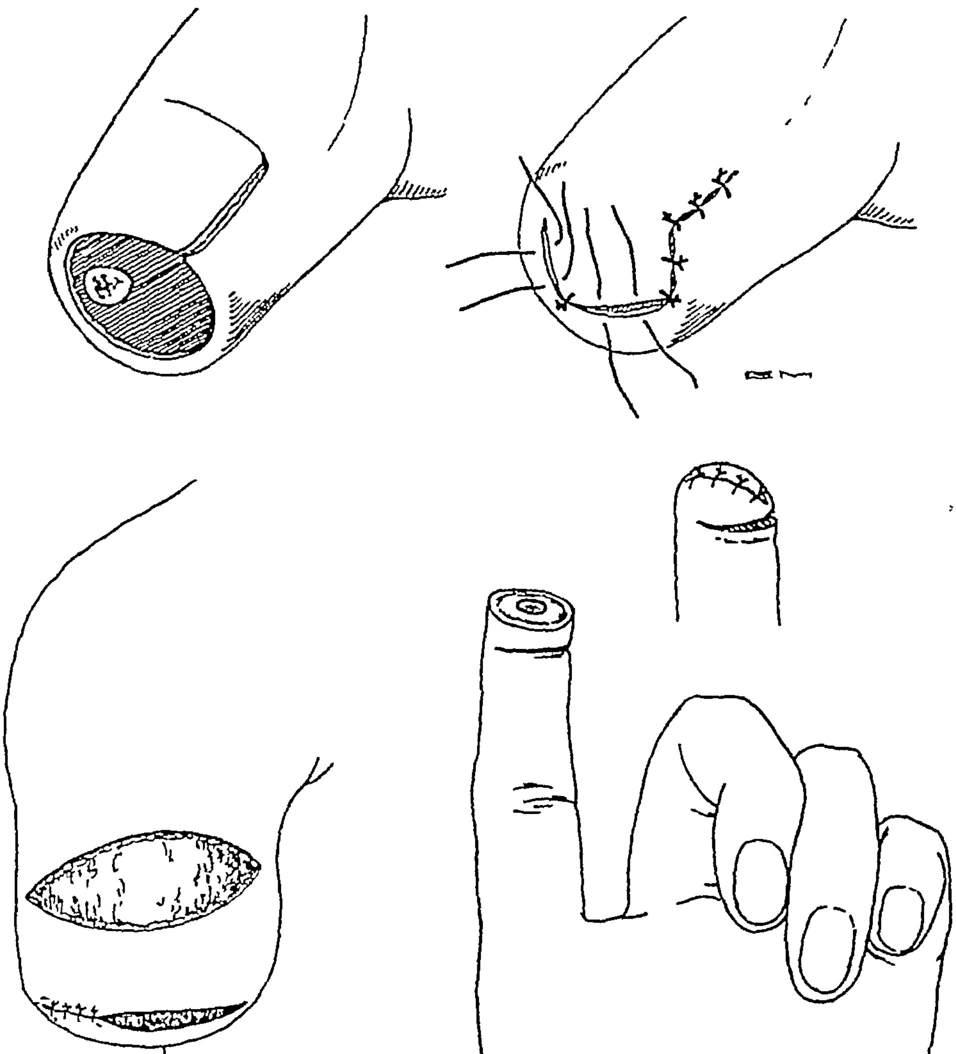


FIG 142 Use of advancement flaps to cover stumps following guillotine amputations (Samter and Klapp)

method of closure consists of first suturing the four angles and then approximating the long sides remaining (fig 140)

(b) *Swinging Advancement Flaps* These flaps are cut from the tissues contiguous to the margins of the part to be covered in such a way that one margin of the defect constitutes one side of the flap and the pedicle forms a part of the reconstructed field when the flap is rotated (figs 141–143). Subsequent severance of the pedicle is unnecessary, as there is no intervening tissue between it and the defect Oval-shaped losses may be thus repaired by rotating over them a contiguous flap of corresponding size, the secondary wound being closed by direct approximation of the margins, triangular

defects may be closed by rotating uni or bilateral rhomboidal flaps from the contiguous margin, and rectangular defects by bilateral flaps taken from above or below the defect

The swinging advancement flap is used extensively by Esser and Imre for the reconstruction of facial defects A large area of skin adjoining the loss is undermined, and, by carefully planned incisions hidden in natural folds, the flap is raised and rotated into the defect through an arc while still attached to a broad base, the length of the incision being about 4 times that of the space through which the skin is to be rotated (figs 144–145) In this way the greatest quantity of skin can be moved through

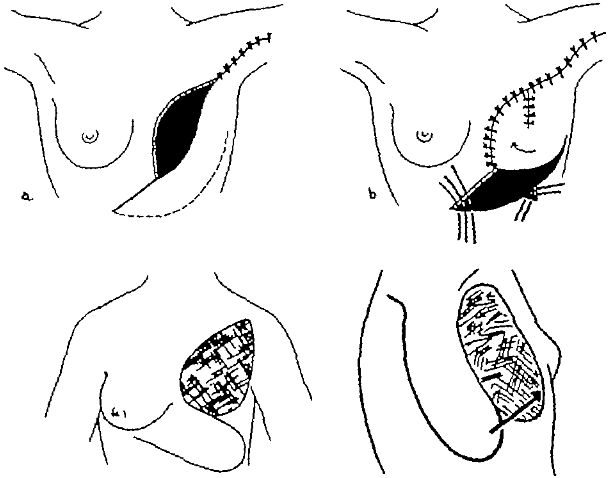


FIG 143 Use of advancement flaps to cover defects following breast amputation (Lexer Ombrédanne, and Tansini)

the smallest possible arc To facilitate rotation and prevent buckling where a large and a small arc have to be united, appropriately sized triangles are removed The viability of the flap depends upon the incorporation of the external maxillary artery or its branches. The method is detailed on page 1371

(c) *Transposition Flaps* (*Z Plastic*) In this method two adjacent flaps with a common side but with their pedicles pointing in opposite directions are outlined by a Z- or S-shaped incision and then raised, transposed and sutured in place (fig 146) The procedure dates back to ancient times, for Hippocrates himself refers to it. Szymanowsky (333) gives credit for its modern use to Denonvilliers (81) who employed it for the relief of ectropion of the outer ⅓ of the lower lid. Since then many modi-

fications of the procedure have been devised for cicatricial contractions in other parts of the body, the choice depending upon the shape and location of the scar and the line of greatest contraction The method may be used to advantage in the release

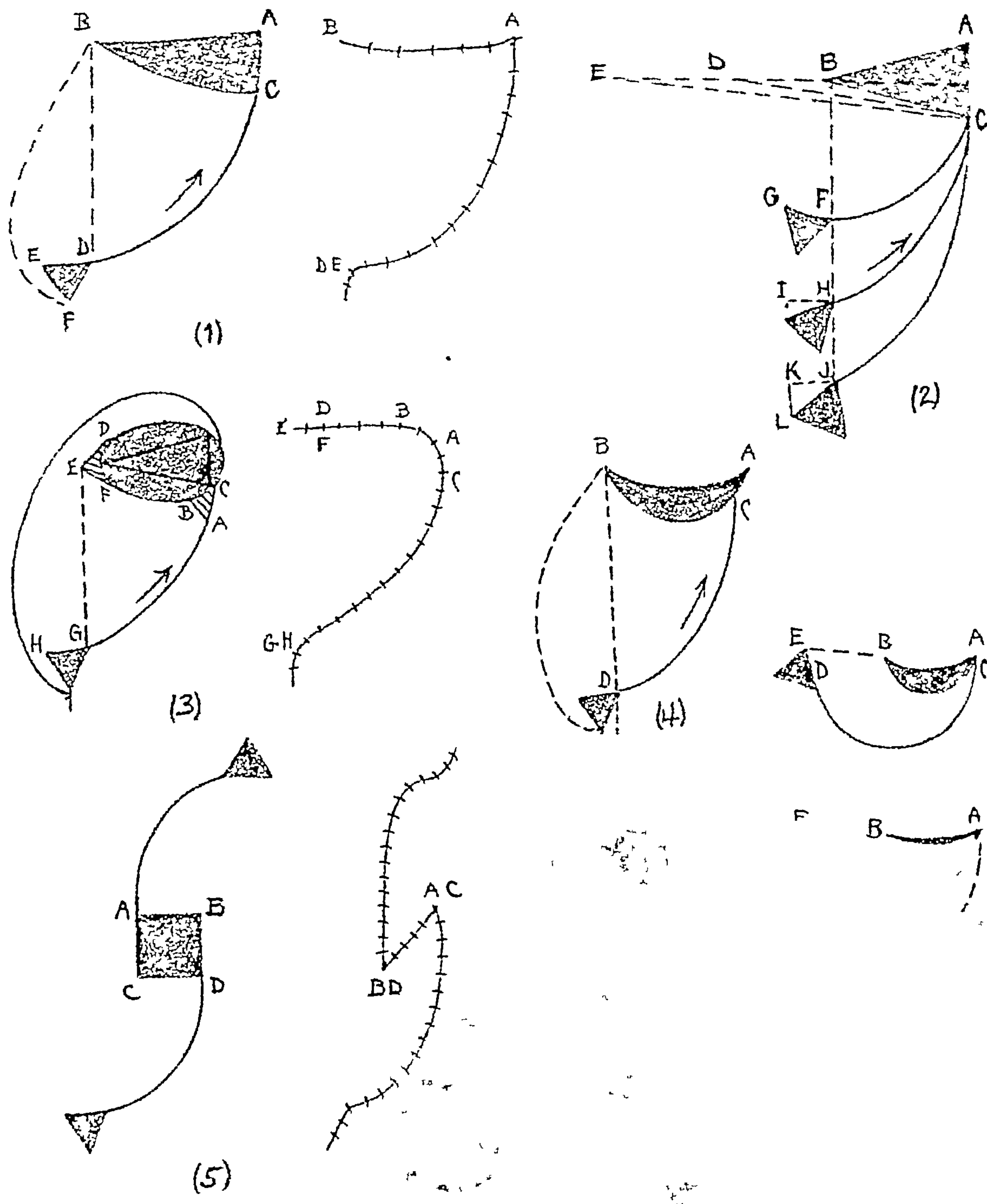


FIG 144 Method of skin closure by adv sents triangular defect, arched incision CE beyond line BD, which is parallel to AC (incision The greater the radius, the more triangle is brought together, G falls on F I of flap If radius is CE, elevation will appe converted into triangle by excising triangles Closure of quadrilateral defect (Blaskovics) smaller radius than that of Blaskovics For de

of linear webbed contractions, provided that the scar tissue is sufficiently vascular to withstand the procedure Davis' (71) description of the technic can hardly be improved upon

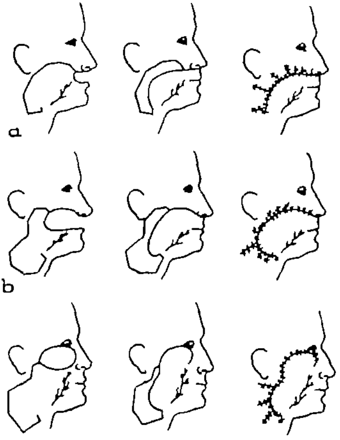


FIG 145 Use of swinging advancement flap for closure of facial defects. *a*, for repair of upper lip defect *b* for cheek defect *c* for lower eyelid defect. (Esser)

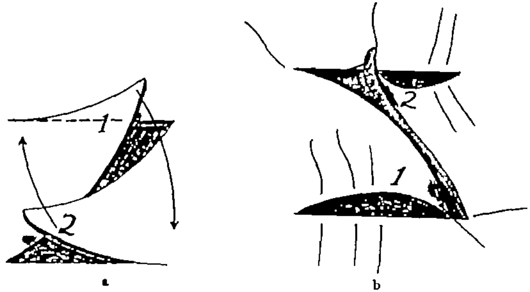


FIG 146. Transposition flaps (Z-plastic) to increase length at expense of width. *a*, two adjacent flaps with common side but with pedicles pointing in opposite directions outlined by Z-shaped incision. *b* flaps elevated transposed, and sutured in place.

"With the scar bridle under tension, mark out the proposed incisions on the contracted area with 5 per cent brilliant green in alcohol The longest line of the Z, which will be called the central line, is laid along the most prominent portion of the bridle or web, and the arms of the Z are marked out on opposite sides of the central line making the pattern an atypical Z or a reversed Z, depending on the condition of the surrounding tissues The arms of the Z begin at each end of the central line on opposite sides and are carried approximately parallel to each other, outward and downward or outward and upward as the case may be, being so placed as to mark out blunt pointed flaps The arms, which are usually about two-thirds of the length of the central line, ordinarily extend to points about the level of the middle of the central line on each side and about half the length of the central line distant The incisions are made following the pattern, and the two broad-based triangular flaps thus formed are undercut and fully mobilized

"If the scar bridle is reasonably thin and flexible or partly composed of fairly normal skin, it is split its full length and utilized as a part of the flaps If, on the other hand, the scar bridle is thick and rigid and is unpromising for use because of poor circulation, an elongated ellipse of tissue, including this portion, is excised and the edges are brought together with a few temporary sutures This sutured wound is used as the long line of the Z, the arms of which are then marked out in the usual way Should scar adhesions be found deep in the tissues after the flaps are raised, they should be removed and all tension relieved before the positions of the flaps are changed After the relaxation incisions are made and the flaps are undercut, the extremities of the central incisions are drawn away from each other, and the triangular flaps gradually change their positions, in other words are transposed, so that the tip of one flap is carried into the angle at the outer end of the arm incision forming the other flap and vice versa The flaps are sutured into position with a few on-end mattress sutures of fine black waxed silk placed at strategic points, and the rest of the closure is made with similar sutures of horsehair The sutured wound is also Z-shaped, but the long line of the Z lies transversely across the original scar pull"

(2) **Rotation Flaps (Indian Flaps).** This term is applied to flaps taken from the immediate neighborhood of the defect and rotated into their new position by more or less torsion of the pedicle (fig 119) These flaps differ from the French type of rotation flap in that they are carried over a bridge of healthy tissue lying between the flap and the defect and require a severance of the pedicle They are used extensively in rhinoplastic surgery and are dealt with in detail under "Total Rhinoplasty" (p 741) Assuming the flap is to be taken from the forehead, the operative steps are briefly as follows The scar tissue over the defect is excised down to a healthy nutrient bed A previously made pattern is placed on the forehead in such a manner that the pedicle when rotated will be under a minimum of tension The pedicle should be as wide as the flap itself and so situated as to include the angular, nasal, frontal, or anterior temporal artery, in order that the flap may be amply nourished It is usually made to lie over the glabella, but if the skin in this region is scarred, it may be formed on the temporal region, the flap being directed obliquely across the forehead, and its free end carried either straight up or to one side, depending upon the length of the forehead and the size of the defect to be covered The flap is outlined and raised in the manner already described, care being taken not to traumatize its margins Hemorrhage is controlled during the process by the application of pressure over the

eyebrows and temporal region When the flap has been completely separated, the individual blood vessels are caught with fine pointed hemostats and tied. The flap is rotated into the defect and fixed to its margins with interrupted horsehair sutures A dressing is applied care being taken to avoid compressing the pedicle. The sutures are removed on the sixth day, and 3 or 4 weeks later the pedicle is divided, the balance of the flap sutured into the defect, and the stump returned to the forehead after opening the suture line

Flaps from a Distance

When the tissues in the vicinity of the loss are either inadequate or unusable because of disease or scarring, or in cases where a secondary defect would be especially objectionable, as, for example, on the face, the tissue for the repair must be transferred from a remote part of the body This is done in one of two ways (1) by regional juxtaposition, whereby the flap, through favorable posture can be made to bridge the space between donor and recipient areas by its own length, and (2) by means of an intermediate carrier

(1) **Regional Juxtaposition Flaps (Tagliacotian Flaps—Italian Flaps)** These flaps are taken from a remote region of the body and brought to the defect by posture, the parts being held in juxtaposition by some form of fixation apparatus until the new circulation is established in the flap A common example of this method is the replacement of a skin loss of the face by a flap taken from the arm Although the method does not leave an additional scar in the vicinity of the defect, a definite objection to its use is the fact that the transplanted skin does not match the surrounding tissues and that the posture necessary to approximate the parts often becomes unbearable.

The details of the technic are described on page 783 Briefly, if the arm is to be used, a flap corresponding roughly to the size and shape of the defect is detached from the underlying biceps muscle with as little damage to the blood supply as possible The margins of the secondary defect on the arm are drawn together The extremity is raised and approximated to the head, and the flap is sutured into the freshened defect on the face (fig 120) Finally, the parts are immobilized by a plaster cast in such a way as to avoid tension on the pedicle The most comfortable position is that in which the forearm is flexed across the top of the head so that the hand hangs down in back of the opposite ear (fig 414-d) To prevent decubitus, portions of the cast are cut away in 1 or days. After the circulation of the flap has become established, a process which usually takes 2 or 3 weeks, the cast is removed, the pedicle cut close to the arm, and the extremity gradually lowered. The rest of the flap is then fitted into the remaining part of the defect.

(2) **Flaps Brought Into Position by Intermediate Carrier** The use of this method applies to cases in which the flap cannot be made to reach the defect directly The technic has already been described

Flaps Other than Skin

Flaps, like grafts, may be fashioned from tissues other than skin.

Muscle flaps have been employed for a variety of purposes. McNealy and Shapiro (242) and others (170) have made use of them for the repair of wounds in large arteries.

A thin flap of muscle contiguous to the blood vessel is rolled around the arterial wound and secured to the vessel by silk sutures passed through the adventitia Beck (17) in 1935, in an effort to furnish the ischemic heart of coronary disease with a new source of blood supply, raised a pedicle of well-vascularized muscle and fat from the chest

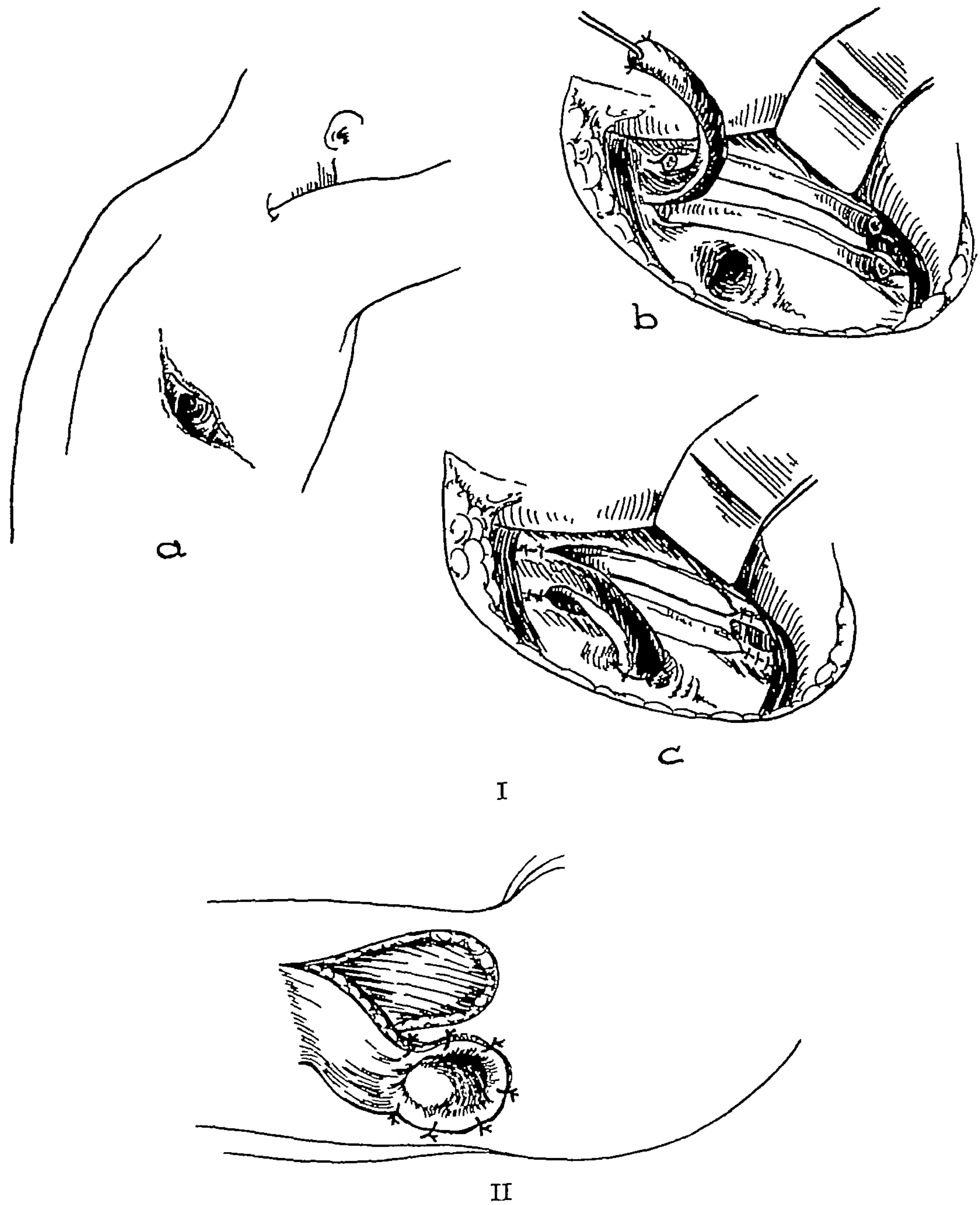


FIG 147 Use of muscle flap to obliterate adventitious cavities when they cannot be collapsed by removal of fibrotic wall *I*, implantation of intercostal muscle flap into fistulous tract (Shenstone) *II*, obliteration of osteomyelitic cavity with contiguous skin-muscle flap

wall and implanted it directly onto the heart muscle with the purpose of bringing the heart into direct contact with the extracardiac vascular bed Cokkins (56) summarizes Beck's operation as follows

"Under gas and oxygen anesthesia the insertion of the left pectoralis major was

mobilised, and a curved incision made to the left of the sternum. A pedicled flap was cut from the lower part of the pectoral muscle , while the upper part of the pectoral was incised a little lateral to the sternum and lifted from the 3rd, 4th and 5th cartilages. These cartilages were then removed, and the intercostal muscles divided laterally, preserving their internal mammary supply The pericardium was opened from apex to base and its serous lining as well as the epicardium, removed in shreds with a burr This caused extra systoles and some cardiac dilatation, which necessitated rest periods. The pedicled graft was then split, and both parts wrapped round the heart, and sutured laterally and posteriorly to the parietal pericardium The intercostal muscle bundles, carrying the internal mammary artery, and the inner margin of the pectoral muscle were brought beneath the sternum and also attached to the pericardium. Finally, the lateral margin of the pectoral was turned in so that its cut surface touched the heart , and the pectoral fascia and skin wound were sutured without drainage."

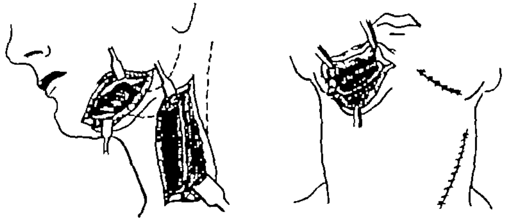


FIG 148 Use of muscle flaps to fill cavities in mandible. *a*, cavity on left side of body of mandible obliterated by muscle flap taken from sternocleidomastoid. *b* cavity on right side of mandible obliterated by flap taken from platysma muscle.

Two obvious questions which will arise at this point are whether such an adhesion will not subsequently interfere with the heart's action and whether the flap, partly deprived of its nerve supply, is not likely to undergo atrophy with a diminished vascularity Only time and experience will furnish the answer O'Shaughnessy (262) in 1936, with a similar objective in view pulled an omental flap through an opening made in the diaphragm and attached it to the heart. While an omental flap is not likely to undergo atrophy, it would seem that the opening thus created in the diaphragm might by its contraction lead to strangulation of the flap Rienhoff (298) suggests the use of muscle flaps to divert the flow of lymph through new channels for the relief of lymphedema

Flaps of muscle are also employed to obliterate osteomyelitic and other adventitious cavities resulting from suppuration and subsequent fibrosis in cases where the cavity cannot be collapsed by a removal of the fibrotic wall (fig 147) Kanavel (179) corrected a depression over the frontal sinus in the following manner "The edges of the skin were freshened and the bridge of skin removed. A flap of hairless skin with its pedicle was outlined on the left forearm and the incision extended downward from the lower

end of the flap for a distance of 2 inches, so as to permit securing an additional area of subcutaneous fat and fascia as large as the flap itself, in other words, the subcutaneous portion of the flap was twice as long and of the same width as the cutaneous portion The forearm was carried to the forehead, and that portion of the flap consisting of fat and subcutaneous tissue doubled under the first portion so as to fill the excavation in the bone The edges of the skin were attached to the skin of the forehead, and the arm held in position by a plaster of Paris bandage In the course of the next 20 days the pedicle of the flap was partially severed at intervals of several days and finally completely detached, after which the remaining free edge was attached to the skin of the forehead "

Kanavel also made use of a muscle flap to obliterate a cavity on the left side of the body of the mandible (fig 148) "An incision was made under the left side of the mandible, the skin dissected upward, and the contents of the bony cavity with its lining removed To fill the resulting cavity with living tissue a pedicled flap was prepared from the left sternocleidomastoid muscle, by using the sternal and a part of the clavicular portion, freeing it from the sternum, and swinging it upward and inward under the skin and deep fascia close to the angle of the jaw so as to insert it into the cavity in the mandible Since the end of this flap would reach only to the symphysis, a second incision was made upon the right side under the mandible, and a flap of platysma muscle with the overlying fat and fascia raised from underneath the skin and turned forward into the remaining space through an opening in the thin shell of bone which formed the anterior wall of the mandible in that position The wound was closed without drainage "

Muscle flaps have also been used to substitute the function of paralyzed muscles in facial paralysis (fig 634), but in this capacity they have proven unsatisfactory, inasmuch as a muscle deprived of its nerve supply soon undergoes atrophy and fibrosis This subject is treated in detail on page 1031

Other flaps, such as those of fat, mucous membrane, fascia, etc , are discussed in the appropriate sections

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CHAPTER III

WOUNDS

For the past two decades the number of accidental wounds has been steadily mounting, as a result of high speed automotive transportation, the more complete mechanization of industry, and the increased participation of our people in active sports "In a press release from the National Safety Council, the toll of accidental deaths and injuries for 1937 has been given as dead 106,000, permanently injured 375,000 and temporarily injured 9,400,000 The estimated cost of this civil carnage was $3,700,000,000 While the deaths from accidents of all causes decreased 4 per cent, from 1936, traffic accidents increased 4 per cent, home accidents decreased 15 per cent, occupational accidents increased 6 per cent and public nontraffic accidents decreased 5 per cent The traffic death rate per hundred thousand of population in 1937 was 30 7, compared to 29 7 in 1936, and represents a rate 62 per cent higher than 1925 and 30 per cent higher than 1933" (1) (fig 149)

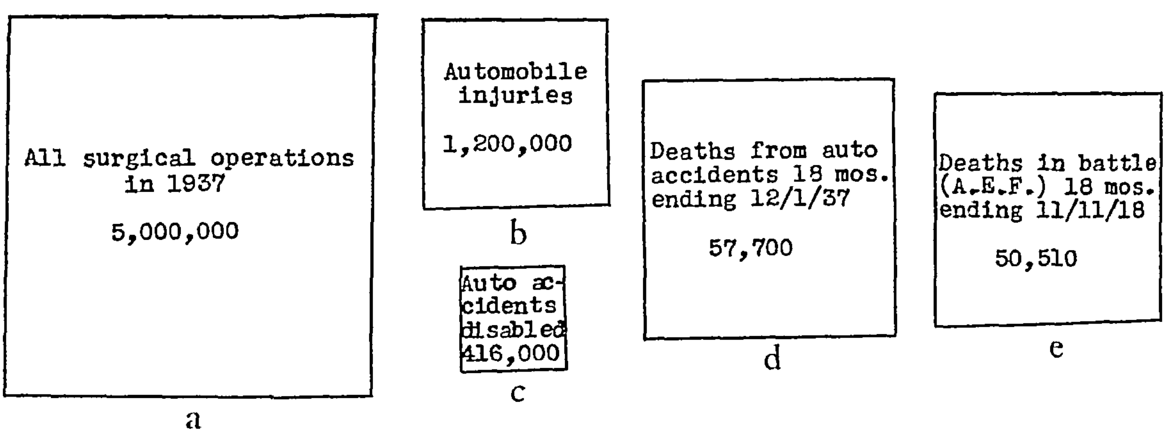


FIG 149 Diagram, illustrating relative importance of automobile as cause of injury and death *a*, all surgical operations, 5,000,000 (A M A Reports on Hospitalization for 1937) *b*, auto accident injuries, 1,200,000 (Report of National Safety Council for 1937) *c*, auto accidents disabled 7 days or more, 416,000 (National Health Survey 1935–1936, Bull No 3) *d*, deaths from auto accidents 18 months ending December 1, 1937, 57,000 (Report of National Safety Council for 1937) *e*, deaths in battle (A E F) 18 months ending November 11, 1918, 50,510 (Report of National Safety Council for 1937) (Borden and Stubbs, Medical Annals, March, 1939)

Inasmuch as a large proportion of these injuries occur in outlying districts and since the nature of the treatment administered during the first few hours will largely determine the difference between early functional and anatomic restoration on the one hand and delayed healing with deformity and loss of function on the other, it is becoming ever more desirable that the general practitioner, upon whom the entire responsibility necessarily falls, be thoroughly versed in their management

Since ancient times the trend in the treatment of wounds has swung back and forth from curative to prophylactic measures The cauterization therapy dominant in surgery during the early part of the sixteenth century was discarded as the result of

a chance experience of the eminent Paré on the battlefield Accustomed to the use of boiling oil, he was forced on one occasion by an accidental exhaustion of the supply to omit its use, and was surprised to find that the wounds healed more readily and without the usual inflammation and sloughing Thanks to this discovery, surgeons were led to discard the former drastic measures and to place greater reliance upon the inherent healing properties of the tissues, and for many years thereafter wound management was limited to the gentlest cleansing and the application of the most innocuous substances (41) The general opinion was expressed by Paracelsus (92) (1536) who wrote "Warily must the surgeon take heed not to remove or interfere with Nature s balsam, but protect and defend it in its working and virtue. It is the nature of the flesh to possess in itself an inate balsam which healeth wounds." About the middle of the nineteenth century, following Lister s announcement of the bactericidal properties of chemicals, prophylactic treatment was rejected in favor of "curative' measures based on the use of germicides. During the World War the wide experience occasioned by the abundant clinical material demonstrated the fact that the orthodox treatment of wounds by means of chemicals was ineffective and often harmful. The generally disappointing results led to the adoption of mechanical sterilization, dependence for wound healing being again placed upon the defensive properties of the tissues. In November, 1914 treatment by "excision and primary suture" was introduced by Gray, Consultant to the British Expeditionary Forces at Rouen, who secured mechanical sterilization by excising en masse a gutter shaped wound down to healthy muscle and united the margins by means of a primary suture. Lewis (66) states that, "from then on the surgery employed in the treatment of war wounds became preventative rather than curative."

WOUND HEALING

A brief review of the changes that take place during the healing of a wound is essential to an understanding of the treatment. The nature of the stimulus which motivates the process of repair after a loss in the continuity of tissues is not definitely established Some investigators believe that the healing process is initiated by mechanical changes in tension when contiguous tissues are divided and base their belief on the assumption that there exists between intact cells a so-called ' contact substance upon which the quiescence of the cells depends. When the tissues are divided this substance loses its inhibitory action and the consequent disturbance in equilibrium among the cells gives rise to the process of repair Haberlands attributes the regenerative stimulus to substances exuded from the margins of the wound which he terms 'necrohormones.' Carrel (17) is of the opinion that the "growth stimulus" is inherent in a substance liberated by the leukocytes, cellular débris, or serum following trauma, and that this substance is closely related to certain protein-decomposition products. It has also been suggested that the growth producing substance belongs to the sulphydryl group (2 10 100)

Academically, the process of wound repair is described as (1) *healing by first intention* and (2) *healing by second intention*, the fundamental difference being quantitative rather than qualitative By 'first intention is understood ideal healing with a minimum of granulation tissue and a minimum of scarring It occurs when the defect is small the patient's resistance good, and when treatment has been adequate. Healing

by "second intention" implies repair with a greater quantity of granulation tissue resulting in a more conspicuous scar It occurs following gross loss of tissue, infection, deposits of foreign bodies, or as a result of poor management (fig 150)

Irrespective of the character of the healing, the changes taking place after a solution in the continuity of tissues are essentially as follows. Immediately following the infliction of the wound there is an extravasation of lymph and fibrin which glues the cut surfaces together The blood vessels dilate, and the surrounding tissues become infiltrated with an inflammatory exudate Subsequently, the damaged cells are either engulfed by leukocytes which migrate into the wound or are digested by tissue enzymes In 24 to 36 hours the endothelial cells of the damaged capillaries proliferate to form vascular buds These tufts unite with each other and soon tunnel out to form new capillaries, which have for their function the absorption and solution of the remaining inflammatory exudate When these vessels have served their purpose they disappear and are replaced by a new set, taking its origin in the deeper parts o

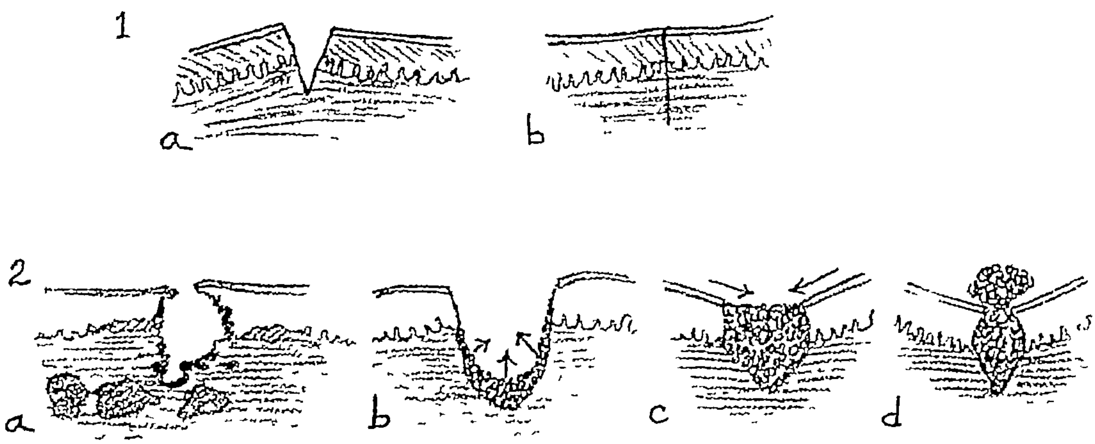


FIG 150 Diagram, illustrating healing of wounds *1*, healing by first intention *a*, incised wound *b*, ideal healing, with minimum of granulation tissue and minimum of scarring *2*, healing by second intention *a*, lacerated contused wound, showing hemorrhagic foci in contiguous tissues *b-c*, healing with formation of extensive granulations and maximum scarring *d*, exuberant granulations, preventing further epithelization (Roux)

the wound and passing upward toward the surface These too arise by a process of budding, but inasmuch as they are enclosed in an adventitia which originates in the fixed connective tissue cells, they are more regular in their development and better supported than are those of the primary set Coincident with the formation of the capillary loops, mesenchymal cells migrate into the wound and bridge the adjacent surfaces These cells arrange themselves in parallel layers, gradually extending upward from the deeper to the superficial parts of the wound The mesenchymal cells, together with the capillary loops, comprise the granulation tissue which not only acts as a protective membrane to the wound, previously covered only with coagulated wound secretions and fibrin, but also serves to destroy bacteria

The origin of the mesenchymal cells is unknown, and several theories have been advanced in explanation According to some authorities, they are ameboid cell- derived from the blood stream and identical with the leukocytes (82) Others cor sider them proliferations of the fixed connective tissue cells, while still another group look upon them as macrophages from the reticuloendothelial system The character of the mesenchymal cells in the granulation tissue varies with the part undergoing

repair For instance, where a resistant tissue, such as bone, has to be absorbed, or when a foreign body is present, they are principally of the large multinuclear cell type, whereas in the case of a less resistant tissue, such as skin, fat, or fibrous tissue, small mononuclear cells predominate

After a variable period the granulation tissue undergoes a transformation into fibrocicatricial tissue. The fibroblasts become elongated and spindle-shaped and in time form bundles of fibrils. It is not certain whether these fibrils are formed by a transformation of the cytoplasm of the cell itself, or by a crystallization of a substance secreted by them. If the latter view is correct, the formation of scar tissue is a specific process rather than a differentiation of mesenchymal cells.

Simultaneously with the above changes, the surface of the wound becomes covered with epithelial cells which advance in pairs from the margins toward the center The method of their spreading is subject to controversy Some think that they are propelled by the division of the pre-existing cells along the wound margins Loeb (69) believes that they advance by a sort of ameboid movement into a jellylike material forming over the wound just prior to their migration In the early stages there are only a few layers of cells, and these do not adhere to the underlying tissues. Therefore, great care should be taken lest they become detached with the dressing As healing progresses, the number of layers increases. The time required for the process depends upon the size of the defect, in the case of small incised wounds the epithelial cover may be complete within 48 hours, whereas large granulating wounds sometimes require months.

The appearance of the scar varies with its age. At the outset it is pink in color, somewhat elevated, rich in cells and blood vessels, and has little tensile strength. Later it becomes pale, due to an obliterative endarteritis and a contraction of the fibroblasts. While the scar serves mechanically to restore the continuity of the part, it in no way takes the place of normal tissue. It is thin, fixed, prone to break down, and liable to undergo keloid formation. Hence, every effort must be made to secure healing by first intention so that the ultimate scar formation may be minimal.

FACTORS INFLUENCING THE RATE OF HEALING

The rate of healing is influenced by many factors, both general and local. Carrel, Lecomte du Noüy and Hartmann (19 20, 65) demonstrated that the rate of repair was directly proportional to the area of the wound and inversely proportional to the age of the patient. Howes and Harvey (53 54) believe that a high protein diet accelerates healing While mild infection and slight irritation stimulate cicatrization, gross infection and trauma, as well as a decreased local blood supply and low temperature, delay healing Experimental studies have attempted to correlate the function of endocrine glands with tissue repair, but the findings are as yet inconclusive.

It has long been held that *vitamins*, especially A and C, are necessary for the repair of body tissues, and that a lack of these elements reduces the rate of growth of the connective tissue and epidermal cells and predisposes to infection. On the basis of this assumption numerous experiments have been carried out in an effort to utilize these vitamins effectively While it is improbable that their oral administration influences wound healing except in cases of avitaminosis (105), yet their direct application in the form of ointments is believed by some to hasten the process of repair On

this premise Loehr (71) and Zeulzer of Germany and Steel (113) of England advocate the application of cod liver oil to wounds, asserting that it is bactericidal, and that by its vitamin content it promotes healthy granulations and stimulates epithelization It is applied to the wound as a thick layer consisting of 40 per cent cod liver oil in sterile vaselin The part is then immobilized, preferably in plaster of Paris, without drainage, and the dressing is left undisturbed for 1 or 2 weeks Horn and Sandor (52) report good results with an oil containing 2,000 Vitamin A International units to each cubic centimeter Luecke (75), Buchheister (13) and others (115) employ an ointment consisting of cod liver oil and honey, which combines the cleansing effect of the latter with the bactericidal and regenerative effect of cod liver oil Following the use of this mixture in infected wounds, Buchheister found that "The leucotropic effect of the ointment was manifested by a greater defense reaction of the tissues against bacteria and their toxins" Davson (24), and Katzenstein and Knake (59) admit the stimulating qualities of cod liver oil but believe that its beneficial action is due not to its vitamin content but rather to its emollient physical properties Pyke (97) is of the opinion that its therapeutic effect is to be attributed to the development of active oxygen as the oil becomes rancid

The main disadvantages of the local application of cod liver oil to wound surfaces are its unpleasant odor and the demand for frequent wound cauterization necessitated by the more active growth of granulation tissue as compared with epithelium

In regard to the effect of *physical agents*, such as ultraviolet ray, infra-red ray, Roentgen ray, diathermy, oxygen, carbon dioxid gas, and irradiated petrolatum on wound healing, reports are at present so contradictory that no definite opinion can be formed It is said that ultraviolet rays in erythema doses applied to the wound surface help to decrease the amount of infection and aid in the formation of healthy granulations Roentgen ray is said to stimulate healing by the hyperemia induced and by its destructive action on the infiltrating leukocytes resulting in a liberation of antibodies and other protective substances, which, when liberated, are thought to exert their action more readily than when contained within the cell Desjardins (25) says "Anyone who has had extended experience with radiology for acute inflammations cannot fail to have been impressed by the prompt relief of pain and rapid resolution of lesions when treated early " Eising (32) found that irradiated petrolatum reduced the bacterial count, stimulated the formation of healthy granulations, and hastened repair Sears and Black (109), on the other hand, found the bactericidal property of irradiated petrolatum so feeble as to be negligible

Hormones (109), embryonic extracts, allantoin, urea, and stimulants containing the sulphydryl radical have also been employed to overcome infection and hasten wound healing

Unfortunately, with so complicated a biologic problem as wound healing and in view of the many associated factors influencing the process, such as the general physical condition of the patient, the nature of the infecting organism, the presence of foreign bodies, and the nutritional state of the tissues, it is difficult to estimate the clinical virtue of any one measure Although these agents offer fascinating possibilities, their use must remain more or less empirical until the underlying factors governing the rate of cell multiplication are better understood

MANAGEMENT OF ACCIDENTAL WOUNDS

The course to be followed in the management of accidental wounds will depend largely upon the extent of bacterial invasion. All accidental wounds must be considered contaminated, bacteria having been introduced by the traumatizing agent, by foreign bodies, such as bits of clothing and dirt, and by unsterile instruments and dressings employed in the first aid treatment. The organisms thus introduced find the zone of devitalized tissue in the margins of the wound favorable for their growth and, if allowed to become acclimated to their new culture media, they multiply and invade the surrounding tissues, converting the contaminated wound into an infected one Obviously, as long as the wound is merely contaminated—i.e , while the bacteria are still on the surface—it is still possible to secure a relative amount of asepsis by means of soap and water cleansing alone or in combination with excision or débridement. While it is generally admitted that mechanical cleansing by deliberate surgical excision of the wound followed by primary suture is the ideal procedure, its applicability is necessarily limited to wounds which are not so large or so deep that excision would endanger important structures, such as blood vessels, nerves, or tendons.

When the wound has become infected—i.e , when bacteria have invaded the tissues—the aforesaid procedures are ineffective. Under such circumstances the bacteria have penetrated too deeply to be reached by cleansing, and excision would not only entail an unnecessary sacrifice of tissue but would open up new avenues of infection and further decrease the vitality of the part through trauma. Therefore, all that can be done is to intensify the natural defenses and protective reactions of the tissues, and the surgeon must content himself with cleansing and débridement followed by a delayed primary or a secondary closure.

The chief difficulty in the way of a decision as to the appropriate treatment is the determination of the exact time when contamination ends and infection begins As a general proposition, the *period of contamination* lasts between 6 and 8 hours (120), but because of the varying character of wounds and the different circumstances occasioning them this period is subject to a wide latitude. For example, in grossly contaminated wounds infection may begin as early as 2 to 3 hours following injury whereas in others where the organisms are few, the pabulum scanty, and the tissues otherwise healthy the period of contamination may extend to 12 hours or infection may never actually establish a foothold

Among the factors which modify the period of contamination are the following (1) The general condition of the patient. Anything that lowers the resistance to infection, such as a coexistent constitutional disease, hemorrhage, or shock will shorten the time (2) The character of the wound. Lacerated, contused, and punctured wounds ordinarily have a shorter period of contamination than do incised wounds due to their irregular edges, the interference with the blood supply, and the likelihood of the presence of foreign bodies. (3) The circumstances surrounding the receipt of the injury and the nature of the first aid treatment received. Infection is more likely to occur early in wounds inflicted out-of-doors, in cases where the patient's skin and clothing were dirty, or when the first aid treatment was instituted without aseptic precautions

First Aid Treatment

First aid treatment aims at the immediate preservation of life and includes: (a) control of hemorrhage, (b) protection of the wound against further injury, (c) relief of pain, (d) control of shock, and (e) prophylactic inoculation

Control of Hemorrhage

In case of emergency where life is at stake, the control of hemorrhage takes precedence over all other considerations, even at the expense of asepsis The method to be adopted will naturally depend upon the location and extent of the hemorrhage and the facilities available If the bleeding vessel is small and unimportant, elevation of the part will usually suffice to bring about spontaneous hemostasis In such instances it is best not to risk further contamination of the wound by direct pressure with tampons of doubtful sterility. When the bleeding is profuse, the vessel is caught with a sterile hemostat if available, otherwise, it is grasped between the fingers, or the vessel proximal to the wound is pressed against some resistant structure Thus, bleeding from the common carotid, vertebral, and inferior thyroid arteries can be controlled by exerting pressure against the transverse process of the sixth cervical vertebra (Chassaignac's tubercle), to control bleeding from the subclavian, the artery is compressed against the first rib by placing a finger in the space between the clavicle and the sternocleidomastoid muscle and exerting pressure downward and inward, bleeding from the facial is controlled by pressure against the mandible at a point immediately in front of the masseter muscle, from the temporal, by pressure against the zygoma just in front of the ear, and from the occipital, by pressure against the superior nuchal line at a point about 4 cm. away from the occipital protuberance

When the bleeding vessel is situated in an extremity, a tourniquet is applied, with just sufficient pressure to cause occlusion of the artery, for if too little pressure is exerted, the vein alone is compressed and the hemorrhage increased, whereas, conversely, if too much is applied, it may rupture an arteriosclerotic blood vessel or traumatize the nerves of the part and lead to paralysis The most desirable tourniquet is a pneumatic cuff, inasmuch as it permits of accurate control of pressure The tourniquet is applied to the thigh or arm, if placed over the leg or forearm, the blood vessels will escape compression between the bones After its application, flexion or extension of the limb should be avoided lest the sudden additional constriction cause further traumatization of the tissues The tourniquet should not be left on longer than is absolutely necessary since, by cutting off the peripheral blood supply, it inflicts further damage on the tissues already devitalized and predisposes to infection and distal thrombosis It should be removed as soon as the patient is in surroundings favorable to aseptic exposure and ligation of the vessel Should it become necessary to leave the tourniquet on for any length of time, it should be loosened for 1 minute every 20 to 30 minutes to allow flushing of the tissues with blood. Under no circumstances should the entire time of its application exceed 1 hour

If the bleeding vessel is too deep to be reached directly or is in a location which does not permit of the use of a tourniquet, the wound may be packed with sterile gauze Should there be a question as to the sterility of the packing, it should be wrung out of some antiseptic solution, such as tincture of iodin, not for the purpose of steri-

lizing the wound, but to insure against the further introduction of bacteria. Hemostasis by means of chemicals is unsatisfactory, in the case of bleeding from large vessels they are ineffective, and in that from smaller vessels the initial vasoconstriction they induce is soon followed by vasodilatation with a recurrence of the hemorrhage.

Relief of Pain

Pain should be promptly relieved by the administration of morphin 0.016 gram (¼ grain) unless there is some doubt as to the diagnosis, in which case the drug is withheld to guard against the masking of symptoms.

Protection of Wound against Further Injury

As soon as hemorrhage has been controlled the wound is covered with a sterile dressing. No attempt is made to remove foreign bodies at this time, since the manipulation would not only aggravate the tendency to shock but, aseptic conditions being absent, would serve to further contaminate the wound. The patient is not to be removed from the scene of the accident until the injured part has been immobilized by a splint, as this reduces pain, prevents further damage to adjacent tissues, facilitates transportation, and, in the presence of an associated fracture, simplifies the subsequent reduction. Should the customary splinting material not be available, well-padded box boards or metal screening can be made to serve the purpose. During transportation every effort should be made to protect the patient against unnecessary jolting.

Control of Shock

The treatment for traumatic shock does not differ essentially from the treatment for shock from other causes (p. 386). It is generally admitted that rest, heat, sedatives, and fluids are all that is necessary to assist the natural tendency toward recovery. Unless there is a hospital within easy reach, the patient is taken to the nearest available house to avoid the trauma from prolonged transportation which is inimical to his welfare. He is undressed with a minimum of disturbance and exposure, clothing being preferably cut away, or, in severe cases, left on, unless wet, until after he has recovered from shock. He is placed in a warm bed in the lateral prone position, the head being turned to one side. In this position he will breathe more easily and in case of vomiting will be less likely to aspirate the vomitus. The foot of the bed is raised about 30 cm. as this elevation induces a better blood supply to the medullary centers. If there is any bleeding from the ears or nose, he is turned on his abdomen and the affected orifices are covered with sterile dressings. Syringing, douching, and packing are contraindicated, inasmuch as these procedures may drive infection into the cranial cavity should an associated fracture of the base of the skull exist. The body temperature is maintained by means of hot water bottles and warm blankets. A falling blood pressure is combated by the administration of parenteral fluids and stimulants in the form of caffein sodium benzoate 0.5 gram (7½ grains), camphorated oil 2 grams (30 minims), or adrenalin 0.3 to 0.6 gram (5 to 10 minims) (p. 389). If there has been considerable hemorrhage, the injection of 250 cc. of properly matched

citrated blood will be of benefit In the absence of a suitable donor, 200 to 500 cc of a 6 per cent gum acacia solution are administered intravenously (p 357)

Prophylactic Inoculation

If the circumstances of the accident and the nature of the wound suggest contamination with bacillus tetanus, bacillus of gas gangrene, or streptococcus hemolyticus, immediate measures should be taken to forestall their development

Bacillus tetanus and the bacillus of gas gangrene are anaerobic organisms found in the alimentary flora of farmyard animals In normal tissue the oxygen of the blood inhibits their growth, but in devitalized tissue, where the blood supply is poor and in the presence of pus organisms which consume the oxygen, conditions for their development become favorable Whereas the tetanus bacillus will establish itself wherever anaerobic conditions are found, the gas bacillus, on the other hand, rarely gains a foothold except in contused and lacerated muscle tissue Therefore, wounds contaminated by roadside dirt, especially under anaerobic conditions, as in the case of a punctured wound or severe muscle damage, should be immediately cleansed by means of wide débridement of all non-viable tissue, and removal of foreign bodies, followed by irrigation with some oxidizing solution such as Dakin's solution, potassium permanganate, or hydrogen peroxid Since the defective blood supply favors anaerobic infection, the use of tight bandages, tourniquets, and splints is to be avoided

Prophylactic injections of antitoxin should be administered as soon as possible after the injury To guard against anphylactic shock, preliminary examinations and tests should be made to determine whether or not the patient is sensitive to horse serum A careful history is taken to ascertain the possibility of any previous injections of serum or a tendency to such conditions as asthma, hay fever, urticaria, or migraine Eye or skin tests for hypersensitivity are made In the former 1 drop of the serum diluted 1.10 is instilled into the conjunctival sac, hypersensitivity being indicated by itching, lacrimation, and edema within ½ to 2 hours following the instillation In the skin test an intradermal wheal is made with the serum diluted 1 10 If the patient is hypersensitive, an extensive erythema develops within 10 to 20 minutes, with characteristic pseudopodialike processes (107) If the patient shows no evidence of sensitivity, 1,500 units of tetanus antitoxin are injected intramuscularly Children receive correspondingly smaller doses Should the tests indicate that the patient is sensitive to horse serum, he is desensitized by the injection of small subcutaneous doses of antitoxin at ½-hour intervals until the full amount has been given Besredka injects 0 5 to 1 cc of the serum subcutaneously and after 3 or 4 hours administers the required number of units Untoward reactions are combated with adrenalin Because the protective effect of antitoxin is limited, the dose should be repeated in 7 days Gage and De Bakey (37) state that the incidence of tetanus following wounds is inversely proportional to the degree of prophylactic administration of tetanus antitoxin The dose of gas bacillus antitoxin is 4,000 units of polyvalent serum repeated in 4 to 6 hours

Unfortunately the prophylactic administration of antitoxin sera does not always prevent the development of the disease, and this fact, together with the tendency of the sera to cause serum reaction and hypersensitivity in individuals who may require subsequent serum therapy, has led to attempts at active immunization In 1925

Ramon (98, 99) prepared a toxoid against tetanus which is said to be more effective than antitoxin and devoid of its disadvantages. Recent investigations by Jones and Moss (56) have shown that a mixture of tetanus toxoid and diphtheria toxoid precipitated with alum makes an effective immunizing agent against both diseases. Similarly, Penfold (94) believes that an alum precipitate of a mixture of bacillus tetanus and bacillus of gas gangrene toxoid is effective against both tetanus and gas gangrene

If the history points to infection with streptococcus hemolyticus, sulfanilamid is administered orally in a dose sufficient to maintain a blood concentration of 10 mg per cent. This is equivalent to 0 1 gram (1½ grains) per kilogram of body weight. Inasmuch as this drug has a tendency to produce acidosis it should be given in combination with equal amounts of sodium bicarbonate Sulfanilamid mav also be administered subcutaneously or intramuscularly in the form of prontosil in doses of 3 cc. per kilogram of bodv weight in 24 hours. It should not be given in combination with coal tar derivatives or saline laxatives because of the danger of methemoglobinuria, and should be used with caution in the case of patients suffering from renal disease, anemia, and cardiovascular disorders. An overdose is manifested by fever, dizziness, headache, anorrhexia, mental dulness, sweating, cyanosis, a rash similar to measles, jaundice, neuritis, and agranulocytosis, but the toxic symptoms usually disappear as soon as the drug is discontinued

Investigation

As soon as the patient has been placed in surroundings where proper facilities are available for his care, he is examined and definitive treatment instituted at once, since a delay of even a few hours mav change a contaminated wound capable of being cleansed and united by means of a primary suture into an infected one that will heal slowly with extensive scarring and impairment of function

General Examination

A history of the circumstances occasioning the wound is of inestimable diagnostic value. While a full account of the details is seldom obtainable, a few facts supplied either by the patient himself or by spectators will go far to establish the nature of the injury (p 529) Such a history is also important as it helps in the detection of other constitutional conditions which may influence the treatment and the choice of anesthetic. For example, the administration of glucose to a patient with a predisposition to diabetic coma may bring about serious consequences If the patient is conscious, the details of the accident and the presence of coexistent diseases can easily be ascertained, moreover the pain will aid the surgeon in localizing the injury But if he is unconscious, a more serious problem is presented since the loss of sensibility may be due to other conditions not determinable at the time such as diabetes, apoplexy uremia, epilepsy, etc.

A systematic, even if hasty survey is made of the entire body beginning with the scalp and continuing to include the face, neck, thorax, abdomen, and extremities, for the possible discovery of internal injuries, since it often happens that immediate attention to an associated visceral lesion will do more to save the patient's life than

the care of the surface wound Obviously, the search for such associated lesions is of particular importance in the case of an unconscious patient who is unable to indicate their presence Unconsciousness usually presupposes shock, and when this state is associated with hemorrhage from the nose, mouth or ears, and with a slow pulse, the presence of skull fracture and cerebral injury is to be suspected (p 529) Bleeding into the pleural cavity can be determined by percussion and auscultation Physical evidence of free fluid in the abdominal cavity would suggest an internal lesion The examination should be supplemented by laboratory and x-ray tests when indicated.

Local Examination

Following the general survey, the injured part is anesthetized and cleansed, after which a search is made for foreign bodies, and the extent of damage to the skin, muscles, tendons, nerves, blood vessels, mucous membrane, and bone, is estimated

Anesthesia. If the wound is trivial and the patient composed, the preliminary hypodermic injection of morphin is usually all that is necessary In the case of more extensive wounds, however, or if the patient is a child, anesthesia is of decided advantage, as it facilitates sterilization of the wound and permits of a more thorough examination and a more careful approximation of the tissues A general anesthetic is best, preferably nitrous oxid and oxygen, vinethene, or cyclopropane, but if for some reason general anesthesia is contraindicated, procain may be employed either as a nerve block or as a circular block outside the wound edges. If the latter method is chosen, it is advisable to defer the injection until after the skin around the wound has been cleansed, so as to avoid the danger of introducing infection into the tissues by means of the needle Fritz and Tanner (36) recommend a pack of a 1 per cent solution of procain applied directly over the wound for from 5 to 8 minutes, or one of a 5 per cent solution for 5 minutes They claim that such a pack prevents distortion of the tissues and produces a desensitized area extending 1 cm beyond the wound edge.

Cleansing of Surrounding Skin As soon as anesthesia has been secured, the original dressing is removed and any bleeding points are caught with sterile hemostats, but no attempt is made at this time to ligate the vessels A fresh sterile dressing is placed over the wound, and the tissues adjacent to it are aseptically prepared to avoid contamination of the wound from the surrounding skin Incrustations of dried blood are softened and removed with swabs dipped in hydrogen peroxid, and grease, if present, is dissolved out with benzene or ether. With a sharp razor the part is shaved, care being taken not to abrade the skin The shaved area is scrubbed gently for 5 to 6 minutes with cotton swabs dipped in green soap and sterile water, the lather being rinsed off with sterile water at frequent intervals After this scrubbing the skin is dried with sterile gauze, swabbed with ether, and washed with 70 per cent alcohol Any superficial ground-in dirt or roadway tar is scrubbed away with a brush More deeply embedded particles are painstakingly lifted out with a pair of fine forceps or excised with a fine cataract knife, for while such particles might be tolerated, it is best to remove them because they usually keep the tissues in a swollen indurated condition, predispose to infection, and in time become encapsuled, leaving permanent tattoo marks After the surrounding skin has been thus cleansed, the part is draped with sterile linen in the usual manner and the wound itself attended to

Cleansing of Wound. The sterile dressing previously applied is now removed, new

gloves are donned, and fresh sterile instruments provided to avoid the carrying of infection into the wound If a local anesthetic is to be used, it is injected at this time. The wound is washed with soap and water, cotton swabs being chosen rather than the more irritating gauze, which is likely to cause mechanical injury The lather is removed at frequent intervals by copious douching with sterile water or Dakin's solution preferably from an irrigating outfit as much as 4 to 10 liters being employed for the purpose During this process the wound is held open by the assistant so that the fluid may reach every crevice This cleansing automatically clears the wound of loose foreign particles, such as blood-clots, fragments of clothing, splinters of wood, pieces of glass, and dirt. The wound is then swabbed with 70 per cent alcohol, douched with ether, and the part redraped

Investigation of Wound. The margins of the wound are now gently but widely separated with sterile hooks and its depth explored for the detection of foreign bodies and injured or severed tendons, muscles, nerves, ligaments, bones, or joints. Considerable judgment is required to determine the extent to which this exploration is to be carried out. For instance in the case of punctured wounds it may entail the soiling of parts which might otherwise have escaped infection, on the other hand, if a nerve, muscle, or joint is directly involved, failure to expose the injury may incur serious consequences. Should there be evidence of injury to muscles, nerves, or ligaments, the parts controlled by these structures must be carefully examined

Definitive Treatment

The management of the wound will depend upon whether it is contaminated or infected.

Contaminated Wounds

If circumstances indicate that bacterial contamination has not progressed to the stage of actual infection, tissue damage is slight, the wound is not in the vicinity of important structures, and the general condition of the patient is good, the ideal procedure is the *excision of the wound en masse*, followed by a *primary suture* either by direct approximation or in case of tissue loss, by means of a graft or flap Thus a compound injury is converted into a simple one, the wound is protected against further bacterial invasion, and there is the greatest likelihood of subsequent healing by first intention. Excision en masse is accomplished by an incision carried around the circumference of the wound at a distance of 0.5 cm. from its margin and extending for the same distance beneath its depth When the entire wound has been excised, all bleeding vessels are ligated and the margins immediately approximated in the manner described on page 69 Briefly, the divided tissues must be made to assume as nearly as possible their former relationships. If the wound is small and shallow, it may be closed by several sutures each being made to incorporate all the layers of the wound. If it is deep and extensive or if it lies across the lines of Langer, each layer is closed individually in tiers from below upward like tissue being sutured to like tissue. This method of closure does away with potential dead spaces and lessens the tension on the skin sutures. Especially important is the approximation of the divided fascia and aponeurosis, since it is these structures which must be depended upon to hold the wound

surfaces in apposition, fat and muscle when sutured are too fragile to lend the necessary support To minimize the surface scar, the skin edges should be brought together without vertical or horizontal deviation and without inversion The deeper structures are united with #000 catgut or fine white silk and the skin by means of fine ophthalmic silkworm-gut, preferably on an eyeless cutting needle The details are given on page 69.

Where the loss of tissue is so great that direct approximation of the wound margins would cause too much tension on the suture line, the necessary relaxation may be secured by an undercutting of the skin margins, or by the introduction of relaxation sutures designed to transfer the tension from the line of union to a more distant site The more the absorption of tension required, the greater should be the distance of these sutures from the wound margin and the larger the amount of tissue included in their bite To prevent their cutting into the skin they are tied over small pieces of xeroform gauze If these measures are inadequate to secure approximation without undue strain, the raw surface is covered with a graft or a flap (Chapter II)

If the wound is still in a contaminated state, but so large or so deep that its complete excision would endanger important structures, such as blood vessels, nerves, or tendons, if doubt exists as to the adequacy of the cleansing (for instance, in the case of a punctured wound), if complete hemostasis is unobtainable, if it is impossible to avoid the formation of dead spaces, or if some necrosis is expected (as in the case of a lacerated contused wound), one must be content with partial *débridement* Under such circumstances, however, the benefits of healing by first intention may still be obtained by means of a *delayed primary suture* After the wound has been débrided the sutures are passed but left untied, and the wound is packed with vaselin gauze If at the end of 24 to 48 hours the appearance of the wound and the general condition of the patient indicate the absence of infection, the gauze is removed and the previously passed sutures are completed The cosmetic results of this procedure will be found nearly equal to those following primary suture, with none of its risks, although closure will be rendered somewhat more difficult due to the infiltration of the tissues

Technic of Débridement Before the wound is débrided, it is essential that it be exposed throughout its entire extent, and to accomplish this it is often necessary to enlarge it by incising its upper layers Débridement should be carried out with discretion Tissues normally exposed to bacteria—namely, the skin and mucous membrane—are highly resistant to bacterial invasion and may therefore be excised sparingly, but subcutaneous structures, such as fibrous tissue, fat, bone, and cartilage which under normal conditions are protected from contamination, offer little resistance and must be débrided more generously The constitutional state and local condition of the tissues also have a bearing on the matter For instance, more extensive débridement is required in the case of patients showing evidence of fatigue, anemia, or nutritional disorders, and in instances where the tissues are in locations meagerly supplied with blood. Surgical cleansing is begun in the deepest part of the wound and carried toward the surface, all detached and hopelessly damaged tissues being removed Soiled areas of bone are chiseled off, bone splinters still attached by means of periosteum, however, unless grossly soiled, are cleansed and replaced Damaged muscle is trimmed to a depth of a few millimeters, or until a healthy base appears, as evidenced by red coloring, free bleeding, and visible contraction. If tendon sheaths or

capsular ligaments are exposed, the uppermost layers alone are resected. Soiled blood vessels and nerves obviously cannot be so excised and are merely douched with normal salt solution. Hematomata between tissue planes are evacuated. Subcutaneous fat, if soiled, is trimmed away, care being taken, however, not to remove so much of it as to cause an interference with the blood supply of the overlying skin. The amount of skin and mucous membrane to be sacrificed will depend upon its blood supply and upon the degree of crushing as indicated by the amount of bleeding from the

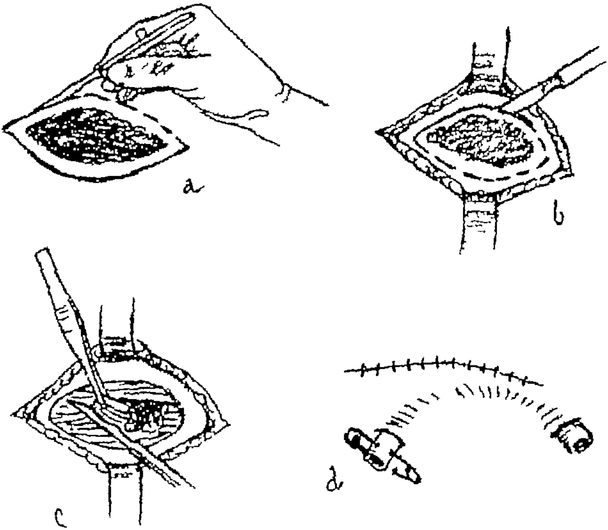


FIG. 151 Débridement of deep contaminated wound. a, contused skin excised in form of elongated ellipse, without sacrifice of healthy skin. Knife discarded and subcutaneous tissue removed throughout extent of contusion. b fascia treated in similar manner c all traumatized muscle removed for distance of 0.5 to 1 cm. on all sides, dissection made parallel to the muscle fibers, and situation of nerves and blood vessels borne in mind Dissection continued until all muscle looks healthy contracts when pinched, and oozes blood when snipped with scissors

cut edges. In any case, as previously stated, it should be trimmed sparingly Even when the blood supply is doubtful an attempt should always be made to preserve every scrap of this tissue, however slenderly attached, for although later some of it may be lost, ultimately there will be a greater saving than if all the damaged skin had been removed at the outset. The bruised edges are cut away in straight lines in order to create a smooth even surface for approximation (figs. 151–152), since irregular margins, even when they heal by first intention, leave noticeable scars.

During the débridement large bleeding vessels are clamped and ligated as encountered. To avoid the danger of tissue damage otherwise occasioned by tentative blind attempts to secure hemostasis in a blood-flooded field, the vessel is grasped with the fingers and the field cleared of blood It is then slowly released and the severed end identified and clamped in the long axis of the vessel with a fine-pointed hemostat, care being taken to incorporate in the bite only the vessel itself (fig 27) It is then ligated and the tissue above the knot excised, since the smaller the amount of non-viable tissue left in the wound, the less the subsequent sloughing Both the distal and proximal ends of severed vessels should be tied, otherwise, secondary hemorrhage may occur through the distal end when collateral circulation becomes established The control of bleeding from small vessels is best deferred until all damaged tissue has been excised, since the bleeding points can be more readily seen on a clean surface.

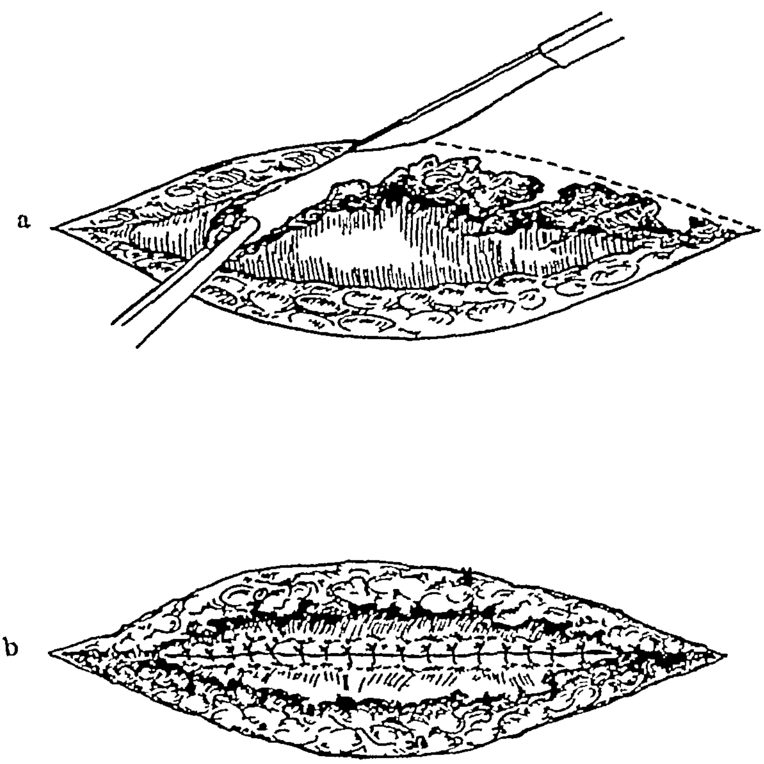


FIG 152 Débridement of superficial wounds *a*, lacerated margins trimmed, to create smooth, even surfaces for approximation *b*, underlying fascia sutured prior to skin approximation (Reid)

Throughout the procedure a frequent change of gloves and instruments is advisable to prevent the carrying of infection into the deeper portions of the wound, for the same reason the wound is repeatedly flushed with hot saline solution for the removal of gross particles and bacteria.

Infected Wounds

If the wound has definitely passed from the contaminated to the infected stage, all thought of healing by primary union must be abandoned and closure delayed until all signs of infection have been eliminated The course and treatment of the infection are governed in a large measure by the character of the infecting organism Therefore, cultures should be made as soon as infection has become established The or-

ganisms most commonly found in infected wounds are the staphylococcus and streptococcus, while those more rarely encountered are the bacillus tetanus and the bacillus of gas gangrene

Staphylococcic infections are characterized by the presence of a thick, creamy pus and a tendency for the process to remain localized. In streptococcic infections, on the other hand, the pus is scanty and seropurulent, and the process tends to spread rapidly by way of the lymph channels, manifesting itself clinically by the appearance of red streaks radiating from the wound, with enlargement and tenderness of the regional lymph nodes

Gas gangrene infection is caused by a large number of anaërobic spore bearing organisms, the most common of which is the Bacillus Welchii. Whereas under ordinary circumstances these organisms are non pathogenic, in devitalized tissue—especially in muscle—they are capable of producing a toxin which the body is unable to neutralize. The affected muscle becomes friable, turns dark brown in color, and assumes a cooked appearance. The most characteristic change is the formation of hydrogen and carbon dioxid gas which is probably the result of glycogen fermentation. The gas spreads between the muscle fibers rather than in the fascial planes It may form as early as 3 hours after the receipt of injury At first it is odorless, but later it becomes putrescent from the associated products of decomposition The pressure of the gas, together with the occlusion of the surrounding blood vessels from the toxic thrombosis, causes an ischemia of the muscle followed by gangrene. The incubation period varies from a few hours to several days Local inflammatory phenomena are absent, but the constitutional symptoms are pronounced Pain is severe, probably due to the pressure of the gas, toxemia is marked and characterized by restlessness, vomiting, a rise of temperature, and accelerated pulse. The parts involved are crepitant and covered with bullae containing a foul-smelling fluid. If the wound is open, gas bubbles can be seen. A smear shows a Gram-positive bacillus, and x ray examination reveals the presence of gas between the muscle fibers

As soon as the condition is diagnosed, all muscular tissue which does not contract or bleed or has changed color is excised. Some muscles may require total excision, and in severe cases amputation of a member is occasionally necessary The wound is left open and Dakinized Ten thousand to 20,000 units of polyvalent antitoxin serum are administered intramuscularly or intravenously and the dose repeated at 4- to 6-hour intervals until 100,000 units have been given.

Management of Infected Wounds

In the case of all infected wounds it is imperative (1) to rid the wound of purulent exudate and necrotic tissue, (2) to limit bacterial growth, and (3) to intensify the defensive reaction of the tissues.

(1) **To Rid the Wound of Purulent Exudate and Necrotic Tissue** Purulent exudates and necrotic tissue, if allowed to remain in the wound, will be absorbed to the patient's detriment increase pain, and delay healing Evacuation is accomplished by means of drainage, the type and duration of which depend upon the character of the wound (p 64) If the infected area is superficial, it is drained by wet dressings changed often enough to prevent retention of secretions. For small deep wounds a satisfactory drain consists of a wisp of 6 to 10 strands of silkworm-gut laid side by side,

a rubber band or an ordinary pipe-cleaner will also serve the purpose Plain gauze drains are to be avoided, since gauze acts more like a plug than a drain More extensive wounds are lightly packed with vaselin gauze and covered with a dressing which is left untouched for a week or longer. As granulation tissue forms, it will force the gauze out of the wound, and after one or two changes closure is usually possible. Such a dressing promotes drainage and relieves the discomfort of frequent removals Where dead spaces exist, tubular drains or cigarette drains are employed When the wound is so located that anatomic barriers interfere with drainage, it may be found convenient to make a second opening at a more advantageous site and thus secure through-and-through drainage Wounds with deep pockets are best treated by continuous irrigation with Dakin's solution

No set rule can be formulated as to the most appropriate time for the discontinuance of drainage, since this will necessarily vary according to the indication In any case, for reasons to be given later (p 496), drains should not be allowed to remain any longer than is absolutely necessary When used for the relief of serous or hemorrhagic oozing, they may as a rule be dispensed with after 48 hours If employed to wall off infection, they are left in until the slough has separated and the infection has been brought under control, as determined by a return of temperature and pulse to normal and by the reduction of organisms to one or less per microscopic field Under no circumstances should a drain be removed and reinserted, since every reinsertion leads to further contamination and additional destruction of tissue

(2) **To Limit Bacterial Growth** Most surgeons feel that the importance of antiseptics and germicides has been greatly overestimated Experience has shown that at best they are capable of penetrating the tissues to a very limited degree, and are therefore capable of inhibiting wound infection only in the first hour or two after injury, while the bacteria are still on the surface Even when they are used early in the treatment, the question arises whether the chemical damage inflicted on the tissues and the consequent interference with the reparative process and with phagocytosis is not too high a price to pay for their doubtful bacteriostatic and bactericidal benefits. Nevertheless, there is some evidence to indicate that these agents, when applied to infected granulations, do to some extent inhibit the growth of bacteria, prevent the spread of infection, and by the exudation they occasion aid in the cleansing and deodorizing of the wound Many such agents have been advocated Those which have been found most satisfactory are the following

(a) *Halogens and Their Derivatives* Of the halogens, Dakin's solution and azochloramid are the most effective.

Dakin's solution is a potent antiseptic and a solvent for necrotic tissue Its preparation is described on page 46 It is essential that it be freshly prepared and that its concentration be between 0 4 and 0 5 per cent, if stronger, it is too irritating and if weaker, it is inadequate It is most efficacious when Carrel's technic is employed. The apparatus consists of (fig 153) (1) a dark-colored glass reservoir of about 1,000 cc capacity To this is attached (2) a rubber conducting tube which leads to (3) distributing tubes in the wound The distributing tubes are made of 3 to 4 mm chlorin-resisting rubber tubing, sufficiently flexible to conform to the irregularities of the wound and yet resistant enough to prevent compression by the dressing and the exudates The terminal ends are tied with linen threads, and the walls perforated with a

punch, the holes being 0.5 to 1 mm. in diameter and 1 cm. apart. These tubes are arranged in the wound in such a way that the liquid may reach every crevice and are held in place by a light sterile fluff gauze dressing The number of tubes to be employed will depend upon the size of the wound. After the surrounding skin has been anointed with sterile oil or grease to prevent irritation, the pinch-cock on the conducting tube is released and just enough of the solution allowed to flow in to cover the wound and keep the dressing saturated without an overflow The required pressure is obtained either by placing the reservoir 4 feet above the wound or by injecting the fluid with a syringe The solution should be renewed every hour or two, since its union with albuminous discharges renders it ineffective When the suppurative process begins to subside, as evidenced by the formation of healthy granulations and

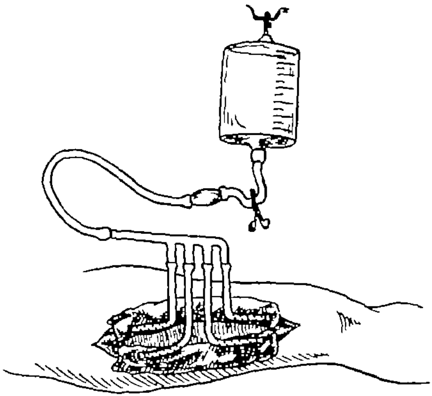


FIG 153 Apparatus for Dakinization of wound, consisting of dark-colored reservoir rubber tubing pinch-cock, small glass bulb for visualization of rate of flow glass distributing tube with side-arms holding perforated rubber tubes For details of use, see text.

the reduction in the number of bacteria to 1 per microscopic field, Dakinization is discontinued.

Kennedy (60) has recently introduced azochloramid, a synthetic chlorin compound with antiseptic qualities similar to Dakin's solution This is preferred by some to the latter agent, inasmuch as it is easier to prepare, more stable does not irritate the surrounding skin and retains its activity in the presence of albuminous secretions. In addition it gives off its chlorin more slowly a single dressing remaining effective for 24 to 48 hours But unlike Dakin's solution, it does not dissolve dead tissue. It may be applied in the form of a wet dressing or as an irrigation in a dilution of 1 3,300 in saline or 1 500 in triacetin

(b) *Dyes* Dyes are often useful in the clearing up of infection. They have anti-

septic qualities capable of acting in extreme dilution, are not rendered inactive by albuminous secretions, and are relatively non-toxic. Bennett, Blacklock, and Browning (8) claim that neutral acriflavin 1:5,000 is the most active agent in reducing surface infection.

(c) *Oxydizing Agents.* Among oxydizing agents, those most frequently employed to combat infection are potassium permanganate in a 5 per cent solution, and hydrogen peroxid. Meleney (86) considers zinc peroxid superior to other oxygen-producing antiseptics because of its slow, constant delivery of oxygen.

(d) *Salts of Heavy Metals.* Salts of heavy metals, such as corrosive sublimate and biniodid of mercury are also employed, but they are inactivated by albuminous secretions, are irritating to the tissues, and when absorbed they are toxic.

(e) *Other Agents.* In the case of wounds containing much necrotic tissue the *maggot therapy*, reintroduced by Baer (5) in 1928, has found a wide field of application. The blowfly larvae not only assimilate necrotic tissue otherwise absorbed to the patient's detriment, but also secrete an alkali which expedites healing and inhibits the growth of bacteria. In this connection Messer and McClellan (88) found that wounds healing in the presence of these larvae develop reactions more alkaline than pH 7.4, in contrast to wounds dressed only with physiologic salt solution, and that sterile larvae produce sufficient ammonia to account for this excess alkalinity, which property is probably responsible for their bacteriostatic action.

Despite its effectiveness, however, the method is cumbersome, control of the maggots within the confines of the field is difficult, and the insects themselves are annoying to the patient. For this reason attempts have been made to isolate the active therapeutic principles. Maurice obtained success with secretions from the maggot to which he gave the name of "permyase," a yellowish-brown liquid with a pH reaction varying from 5.8 to 6.3. He claims that this substance contains all the active therapeutic properties of living maggots without their objectionable features. Robinson (103) suggests that the efficacy of the maggot treatment may be due to the urea and allantoin excreted by the insects.

Urea when applied to wounds is said to promote healing by stimulating the proliferation of mesenchymal and epidermal cells. Being mildly bactericidal and proteolytic in character, it removes débris and incrustations, causing sloughs to disappear, no matter how sluggish the local metabolism, and at the same time deodorizing the wound. It is soluble in water and forms a bland, stable, and non-toxic solution. It is employed locally in solutions varying from 2 to 30 per cent, or the crystals may be used as a dusting powder on the surface of the wound and covered with cellophane (50). Muldavin and Holtzmann (89) first irrigate the granulating surface with a saturated solution of urea until it is freed of all discharges and necrotic material. Following this procedure, they cover the wound with urea crystals over which they place a layer of waxed paper to prevent the granulations from adhering to the dressing.

When *allantoin* is chosen, it is used either as a 0.4 per cent solution or as a 2 per cent ointment.

(3) **To Intensify Defensive Reaction of Tissues.** Since antiseptics at best are capable of penetrating the tissues to only a very limited degreee, their value is necessarily restricted to the destruction of bacteria present on the surface of the wound. So far as the more deeply embedded organisms are concerned, reliance must be placed

In case the granulating wound epithelizes so slowly as to retard convalescence, it is advisable to excise the granulation tissue and resurface the wound either by means of an advancement flap or a skin graft These procedures save time and minimize the amount of contraction

General supportive measures must not be neglected, especially in long-drawn-out cases Rest, maintenance of fluid intake, adequate elimination, and an easily assimilable nutritious diet have a favorable influence on healing Systemic conditions, such as diabetes, nephritis, and cardiac lesions, should be appropriately managed Biologic treatment to aid phagocytosis and the production of opsonins, agglutinins, bacteriolysins, and antitoxins by the use of sera, vaccines, and blood transfusions from immune donors is of debatable value Polyvalent antistreptococcic serum in 10- to 20-cc doses has been employed in an endeavor to protect the phagocytes from the crippling effect of the toxin The demonstration that the staphylococcus produces an exotoxin has stimulated attempts at active and passive immunization A staphylococcic antitoxin has been prepared from the serum of an immunized horse Dolman (26) believes that staphylococcic antitoxin offers the most promising type of specific treatment at present available for acute staphylococcic infection A staphylococcic vaccine has also been elaborated, but its use would seem to be contraindicated in the presence of infection, which in itself is sufficient to stimulate the body without the addition of a vaccine Blood transfusion for the purpose of furnishing healthy leukocytes, complement, and antibodies, is probably the most effective means of combating wound infection (p 352)

Until a short time ago the efficacy of chemotherapy was limited to the treatment of certain protozoon and spirochaetal infections But the recently introduced sulfanilamid, a name given by the Council of Pharmacy and Chemistry of the American Medical Association to the compound para-aminobenzenesulfanilamid, has proven to be a valuable chemical therapeutic agent (28) (p 269) Its action is probably bacteriostatic, since experimental evidence indicates that it is not bactericidal and that it does not stimulate phagocytosis It seems to be specific for the beta-hemolytic streptococcus and has been used to advantage in infections caused by other organisms, such as streptococcus viridans, pneumococcus, meningococcus, gonococcus, colon bacillus, and staphylococcus (p 981) Although sufficient time has not yet elapsed for the proper evaluation of the effects of this drug, nevertheless the encouraging results obtained from its use thus far have given rise to the hope that more agents will soon be found, capable of exerting a similar action on other organisms

Dressing and Immobilization

The final step in the treatment of wounds is the application of a suitable dressing to prevent the introduction of fresh infection, protect the part against local irritation from wound secretions, and afford mechanical protection against trauma Clean wounds on exposed surfaces or those in the vicinity of the eyes, nose, and mouth, which are likely to become contaminated from secretions are painted with a varnish composed of colophony 12 grams, compound tincture of benzoin 16 grams, Tolu balsam 4 grams, iodoform 4 grams, and ether 150 cc , and then exposed to the air Under all other circumstances a dressing is indispensable, but its size and material cannot be arbitrarily stated in view of the varying character of wounds Too great an eagerness to protect the wound by a voluminous dressing may lead to a locking in of the secretions,

while on the other hand nothing is gained by the use of one too scanty. Generally speaking, if the wound has been closed without drainage, it is covered with a few layers of sterile dry gauze held in place by means of a bandage. But if a discharge is expected, a larger dressing must be employed to provide for its absorption.

The dressing is best applied with the patient in the position he will later assume in bed in order that its relation to the wound may remain the same. The manner of application is as follows. That part of the dressing which is to lie directly over the wound should consist of some non-adhering material. Silver foil as suggested by Halsted, or 1 or 2 layers of xeroform gauze serve the purpose well. Over this are superimposed several layers of gauze covering a wide margin of skin around the edges. This material absorbs whatever secretions may collect and adapts itself readily to the outline of the part. The choice between the use of moist and dry gauze is a matter of personal preference. The former is softer and more adhesive, while the latter absorbs secretions more readily and is less likely to encourage bacterial growth. Over this is applied a thick layer of absorbent cotton which serves to reinforce the capillary action of the underlying gauze, protect the wound from injury, and equalize the pressure. The dressing is held in place by means of a roller bandage, which also serves to immobilize the part. In applying the bandage it is important that only enough pressure be exerted to keep the edges of the wound in contact, limit oozing, and obliterate dead spaces. Too great a pressure will complicate healing by interfering with the nutrition of the part. Finally, the bandage is supported by adhesive strips placed circularly so that the ends overlap, and these are reinforced by additional strips placed longitudinally. Provision is made for the evaporation of the secretions through spaces left between the strips. The strips may be made to adhere more firmly if the zinc oxid surface is passed through a flame immediately before its application. If the adhesive plaster is to be applied directly to the skin, the part should first be shaved. If drainage was resorted to, the dressing should be applied in such a manner as not to compress the drain.

When a wound requires frequent changes of dressings, Overholt (91) uses applicator sticks wrapped in adhesive tape and joined together with rubber bands (fig 155). This permits of a ready change of dressing without resort to new adhesive strips. The technic is as follows "A strip of adhesive tape the size depending upon the size of the gauze covering the wound is stretched out on a table with the gummed surface up. Three fragments of an applicator stick are used, two are cut so that they are as long as the adhesive strip is wide, and the third is cut ½ inch longer. The longest stick is placed across the adhesive strip 1½ to 2 inches from one end. Each end of the stick extends about ¼ inch beyond the edges of the adhesive strip. The other two sticks are placed parallel and next to the first so that their ends are even with the edge of the adhesive strip. The short end of the adhesive strip is then folded over these applicator sticks. The first stick holds the rubber band while the second and third keep the end of the straps flat when the rubber band is in place and prevent the strip from folding or doubling up. Two of such strips are placed on each side of the dressing opposite each other and ordinary rubber bands are placed between. The adhesive straps are so placed that only the adhesive part is on the skin and the folded end extends over the gauze dressing. The free ends of the strap should be 4 or 5 inches apart over the dressing for most wounds. As a rule the proper tension on the strap is obtained when

the rubber band itself is stretched out to about twice its normal length so that if a $2\frac{1}{2}$ inch rubber band is used the free ends of the adhesive straps should be 5 inches apart Too much tension will tend to draw the adhesive straps together as so often happens when an inelastic tape or gauze bandage is used to tie the three ends of the adhesive straps together It is important that none of the adhesive portion of the strap come in contact with the gauze of the dressing as a change of the gauze will then not dislodge the straps which should be more or less permanent. If care is used in making the strap and if they are correctly placed on the wound, they will remain in position for a week or more and thus create a great saving in the cost of material for the care of draining wounds"

In circumstances wherein it becomes necessary to keep large raw surfaces in apposition, to obliterate dead spaces, or when a skin graft has been applied, a marine sponge

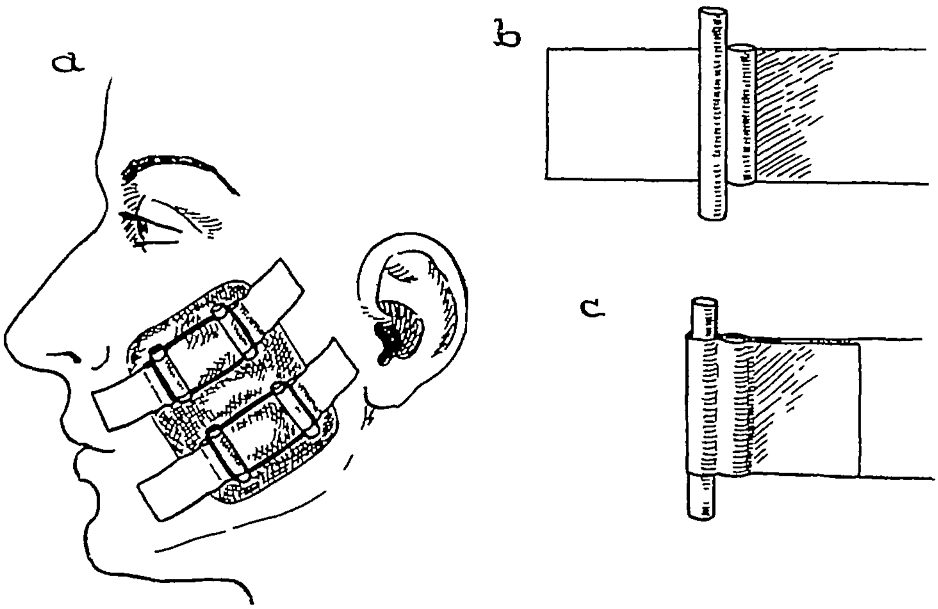


FIG 155 Adhesive applied, to permit ready change of dressing *a*, dressing held in place by adhesive straps incorporating applicator sticks held together by rubber bands *b–c*, method of applying adhesive around applicator sticks For details, see text (Overholt)

or inflatable rubber bag incorporated in the dressing will effect the necessary pressure. The details for the application of such a dressing are given on page 124

After the part has been dressed, it is placed in the most favorable position for healing Where the circulation is strong, it is elevated, and where sluggish, it is lowered When contraction is anticipated, it is so placed as to permit of maximal function The part is then immobilized, for movement, especially in the early stages of repair, disturbs the agglutination of the wound edges, predisposes to hemorrhage and infection, causes pain, and interferes with healing by traumatizing the granulations Billroth (9) emphasized the importance of rest "Absolute rest of an injured part is always necessary—because injurious substances are taken from the wound into the blood Hence, every muscular movement and every consequent congestion of the wound—in short, everything that drives the blood and lymph more strongly into the vicinity of the wound may eventually prove injurious" Of late the importance of rest has again been stressed in the Orr treatment of osteomyelitis

If the ordinary dressing does not supply the required immobilization, it can fre-

quently be obtained by the addition of several reinforcement strips of zinc oxid plaster or elastoplast. Wounds in the vicinity of joints, especially in children where restraint is necessary, are best managed by the application of padded wooden splints.

The details involved in the change of dressings and removal of sutures are given on page 495 Generally speaking, the dressing is changed only when it becomes soaked or displaced, or when access to the wound is necessary for the removal of stitches or drains. Frequent changes are harmful, as each dressing inflicts a certain amount of trauma It may be recalled that early in the process of epithelization the migrating cells are not firmly attached to the underlying surface, and the removal of a dressing during this phase of healing will tend to dislodge them and thus delay repair In the case of clean wounds, unless there is some special indication such as pain or fever, the dressing is not changed until the sutures are ready to be removed, profusely draining wounds however require frequent changes to prevent irritation and maceration of the skin. Before removal of the dressing the part is draped, and throughout the procedure sterile instruments are used in order to avoid contamination. As a rule, the dressing comes off easily, but if it adheres, it may be soaked loose with normal salt solution, sterile oil or hydrogen peroxid.

No specific time can be set for the removal of the sutures, as it depends upon the general condition of the patient and the character of the wound. Ordinarily skin sutures are removed on the third or fourth day, the wound being supported for several days thereafter by strips of adhesive plaster applied to the skin outside the wound and tied with tape over the dressing Tension sutures are allowed to remain for 7 to 10 days, but no longer, since after this time they are apt to cut through the tissues

Treatment of Special Wounds

Contused Wounds. A contused wound is one produced by a blunt stationary instrument, such as a policeman's club or the fist, the damage inflicted being confined to the subcutaneous structures while the skin remains intact. Rupture of the blood vessels results in an extravasation of blood into the surrounding tissues, the amount of effusion depending upon the location of the part. Where the subcutaneous tissue is loose—for instance, in the eyelids—it may be considerable, whereas in localities where the blood vessels are supported by dense connective tissue it is comparatively slight. As a rule, the extravasated blood becomes absorbed, but it may undergo infection or become cystic.

This type of wound is frequently difficult to manage, especially when contaminated material has been ground into the skin The part is cleansed, and foreign bodies are carefully removed the particles being either scrubbed from the skin with a stiff brush lifted out with a fine forceps, or excised with a cataract knife. If allowed to remain they not only interfere with healing but leave unsightly tattoo marks To limit the extravasation the part is placed at rest and elastic pressure or cold compresses are applied. At the end of 4 or 5 days physical therapy in the form of heat and massage is instituted to promote absorption of the extravasated blood. Should hematomata still persist, they are evacuated under aseptic precautions either by means of an aspirating needle or through an incision made for the purpose In the event of subsequent infection, the abscess is incised and treated like any infected wound

Incised Wounds An incised wound is one caused by a sharp moving instrument,

such as a knife The margins are clean-cut and show little damage Although such wounds are contaminated, the amount of necrotic tissue and bacteria present are usually so small that if properly cleansed they may be safely closed by means of a primary suture without drainage If the instrument entered the tissues at an acute angle, the beveled margins should be so trimmed as to lie at right angles with the surface in order to improve their blood supply and secure a firmer union and a better scar If for some reason such trimming is not practicable, the danger of sloughing will be lessened if the sutures are placed farther away from the skin edges than is customary (fig 156) Distortion of the thin layer of marginal tissue can be obviated by the application of a snug bandage (42)

Lacerated Wounds. A lacerated wound is one produced by a dull moving body, such as an automobile wheel, and is characterized by ragged, irregular, contused margins and the presence of ground-in roadway dirt and grease as well as other foreign bodies The skin may have been stripped from the underlying parts, muscles and tendons torn

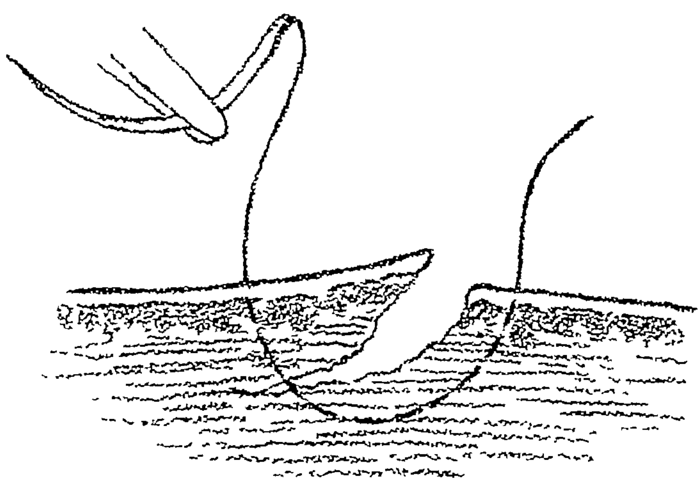


FIG 156 Method of closing beveled wound To avoid danger of sloughing in cases where margins cannot be trimmed to lie at right angles with surface, sutures passed at some distance from wound edges For details, see text

from their attachments, nerves lacerated, bones crushed and comminuted, and joints laid open As a rule hemorrhage is slight, due to the retraction of the inner coats of the blood vessels, and suppuration frequently follows, owing to the severe tissue damage, the interference with the circulation, and the presence of foreign bodies

The management of lacerated wounds has been discussed in the general section Briefly, if the wound is small, and has come under observation before the stage of contamination has passed, it is excised en masse, and closed by means of a primary suture If its location or size is such that excision would be impracticable and doubt exists as to the adequacy of the cleansing, the dead tissue is débrided, a drain is introduced, and the wound closed only in part until such time as the vitality of the tissues may be more accurately determined If closed completely at this time, the inflammatory exudates may press upon the adjacent parts, and the consequent interference with the blood supply may lead to sloughing

During the process of healing, distortion of the soft parts by contraction may be prevented by the attachment to both sides of the wound of strips of adhesive tape to

which ordinary dress hooks have been sewn These hooks are connected by rubber bands in such a manner as to exert continuous traction in the desired direction (fig 157)

Punctured Wounds. A punctured wound is caused by a sharp-pointed instrument. Its external appearance gives no indication as to the extent of the underlying damage even an insignificant wound may be associated with serious internal injury The danger inherent in these wounds lies largely in the anaërobic conditions which they afford for the growth of spore-bearing bacteria, and the poor facilities for drainage They should, therefore, especially when contaminated by road soil, be laid open along the entire length of the canal foreign bodies should be sought for and removed, the tract throughly irrigated by means of an oxidizing agent, such as hydrogen peroxid,

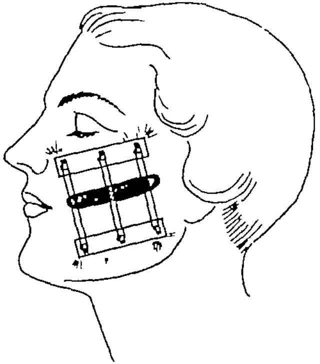


FIG. 157 Dressing to prevent distortion of soft parts Adhesive strips with dress hooks attached to either side of wound. Rubber bands stretched between hooks, so as to exert continuous traction in desired direction.

and drainage instituted. Fifteen hundred units of tetanus antitoxin should be ad ministered as soon as possible following the injury

Bites constitute one type of punctured wound, and the treatment will depend upon the animal responsible. *Human bites* almost invariably become infected and are likely to be serious, as the causative organism—i.e , anaërobic streptococci spirilli, and fusiform bacilli of Vincent's group—are highly virulent. In such cases, no attempt should be made to secure primary closure. The wound is cleansed and débrided in the usual manner, irrigated with an oxidizing agent such as potassium permanganate or hydrogen peroxid drained, and treated with wet dressings. If there has been much crushing of tissue, antigas gangrene serum should also be administered Lowry (74) advises that human bites be cauterized with fuming nitric acid and flushed with cold water Bates (6) excises the entire area with an electro-cutting knife under nitrous oxid and oxygen anesthesia. Smith and Manges (112) report good results with

Roentgen irradiation in conjunction with surgery They employ a dose of 50 to 100 R , repeated daily or weekly, the interval depending on the patient's reaction

Dog bites, in the absence of hydrophobia, usually do not become infected The wound is cleansed and dressed in the usual manner If the identity of the dog is in doubt or the animal is known to have rabies, the wound is cauterized with nitric acid, and Pasteur's (93) treatment, which consists in the establishment of an active immunity by graduated injections of the attenuated virus, is instituted A *cat bite* is apt to become infected and is treated accordingly A *horse bite* takes on the character of a pinch rather than a bite and is treated like a contused wound All animal bites call for the administration of antitoxin if the skin is broken

Gunshot wounds vary in character according to the nature of the missile responsible for their infliction and the velocity with which it strikes the body A bullet fired at short range will produce a punctured wound through the soft tissue, drill a clear hole through the bone, and pass out of the body The wound of exit is usually larger than the wound of entry If the bullet was fired at long range or if its shape was changed in recocheting, there is apt to be extensive laceration and contusion of the soft parts with shattering of bone, the bullet usually remaining embedded The detailed treatment of these wounds is discussed on page 558 Briefly, unless the bullet lies near the surface, inside a joint, or near a vital organ, it is best left undisturbed, the tract being laid open, drainage provided, and a wet dressing applied In any case, the wound should not be probed, as this may spread infection

Complicated Wounds. A complicated wound is one that involves special structures, such as tendons, nerves, blood vessels, bones, etc

Tendon Wounds

The repair of tendons is a well-established procedure, having been practised since ancient times As far back as 1363 Guy de Chauliac, the father of surgery, wrote "I myself have seen and heard of many instances in which nerves and tendons have been divided and have been so perfectly restored by suture and other aids that afterwards it seemed incredible that they had been divided "

A brief review of certain anatomic features will aid in the management of tendon wounds Tendons are bundles of parallel fibers of collagenous tissue insecurely bound together by means of connective tissue which sends in trabeculae between the bundles to form the endotenon For surgical purposes, tendons are classified as follows: (1) Those surrounded by well-developed synovial sheaths These tendons are poorly supplied with blood and are therefore subject to infection and heal slowly For this reason their repair should be undertaken only under the most favorable circumstances (2) Those without synovial sheaths These tendons are surrounded by a loose, areolar, fatty connective tissue known as paratenon which serves the purpose of a gliding mechanism Their blood supply is more abundant than that of sheath-enclosed tendons, hence, their resistance to infection and their healing properties are better and the results of repair are accordingly more favorable

When a tendon is severed, the proximal stump—i e , the part which is attached to the muscle—retracts, the degree of retraction being greatest in the case of long-sheathed tendons, in those attached to strong muscles, and in those taking a circuitous course If the cut tendon is enclosed in a sheath, it will remain rounded and unattached, but

if not so enclosed it will in time adhere to the surrounding structures. Following end to-end approximation, repair takes place by a proliferation from all parts of the divided tendons, and after 10 to 14 days the newly formed tendon filling the gap can scarcely be distinguished from the old. Mason and Shearon (81) state " the tendon ends start to proliferate about the fourth or fifth day after suture and to send out bands of cells and fibrils into the gap tissue beyond It is shown by histologic study of healing tendon sutures that union is effected first by proliferation of the sheath tissues This union serves to reestablish continuity in a few days. After the fourth or fifth day the tendon itself begins to proliferate and to send cells into the callus, and, if the gap is not too great it mav be bridged bv tendon cells in about two weeks.'

Preliminary Considerations. When feasible, severed tendons should be repaired at the earliest possible moment, since primary repair offers the best prospects for maximal functional results. If delayed, it may lead to permanent shortening, adhesions, and atrophy Despite its admitted advantages, however, immediate repair should not be attempted if there is the least likelihood of infection In such instances the proximal and distal ends of the divided tendon are located and fastened together to limit their retraction and to facilitate identification at a subsequent operation. Four to 6 months after complete healing the ends may be united in a clean field. Tendon repair demands the strictest adherence to an aseptic and atraumatic technic in order to reduce the formation of scar tissue to a minimum and thus prevent subsequent adhesions. All dissections should be made with a sharp knife along normal cleavage lines, care being taken to avoid traumatizing the tendon sheath, the formation of hematomata must be guarded against by meticulous hemostasis, particular precautions should be exercised not to damage the tendon by drying, sponging, by the use of chemicals, or by unnecessary handling with forceps. Sponging is done with cotton pledgets moistened in normal salt solution and the exposed tendon is protected with wet cotton packs. Eyeless needles armed with the finest non irritating material should be employed For small tendons needles and silk used in arterial repair are especially applicable. Sutures should be tied in such a manner as to prevent the strangulation of the tissues, and knots should not be interposed between the divided tendon ends. Good light and adequate assistance are prime essentials

General anesthesia is preferable because of the length of the operation, and because the blood pressure cuff, which is essential to a bloodless field, soon becomes unbearable to a conscious patient. The draping should be so arranged that the part controlled by the tendon may be observed during operation.

Primary Repair Immediate tendon repair is feasible only when the circumstances are such that closure of the wound can be obtained by a primary suture when the patient comes under observation within 2 or 3 hours after receiving the injury, and when every facility for careful aseptic surgery is available. If the wound was inflicted by a soiled instrument if the skin and clothing were dirty at the time of the accident or if first aid treatment was given without due regard to asepsis, repair must be delayed.

The damaged tendon is identified and the proximal end, if retracted is milked down until it can be grasped with a forceps. This process may be facilitated by flexing the joint. Masser makes the proximal end more accessible by relaxing the muscle with a local anesthetic. If the end cannot be brought down by these manoeuvers, and the sheath is intact, a probe is inserted into it until the tendon is encountered whereupon a slit is made over the probe and the tendon exposed One end of a suture is then

passed through the end of the tendon and the other fastened to the probe A pull on the probe will draw the stump down to the desired point The severed ends are then matched and approximated

There are several methods of passing the sutures. The simplest is the following. With the tendon ends held by a forceps, 3 or 4 wide mattress-sutures of black braided silk on an eyeless needle are passed through corresponding points in each segment 1 cm away from the severed ends, care being taken that each suture passes through the same plane of both segments Before the sutures are tied, the tendon ends are cut off flush just beyond the point grasped by the forceps The sutures are then tied under sufficient tension to appose the segments but not so tightly as to angulate the fasciculi A few additional interrupted sutures are passed to improve the apposition The

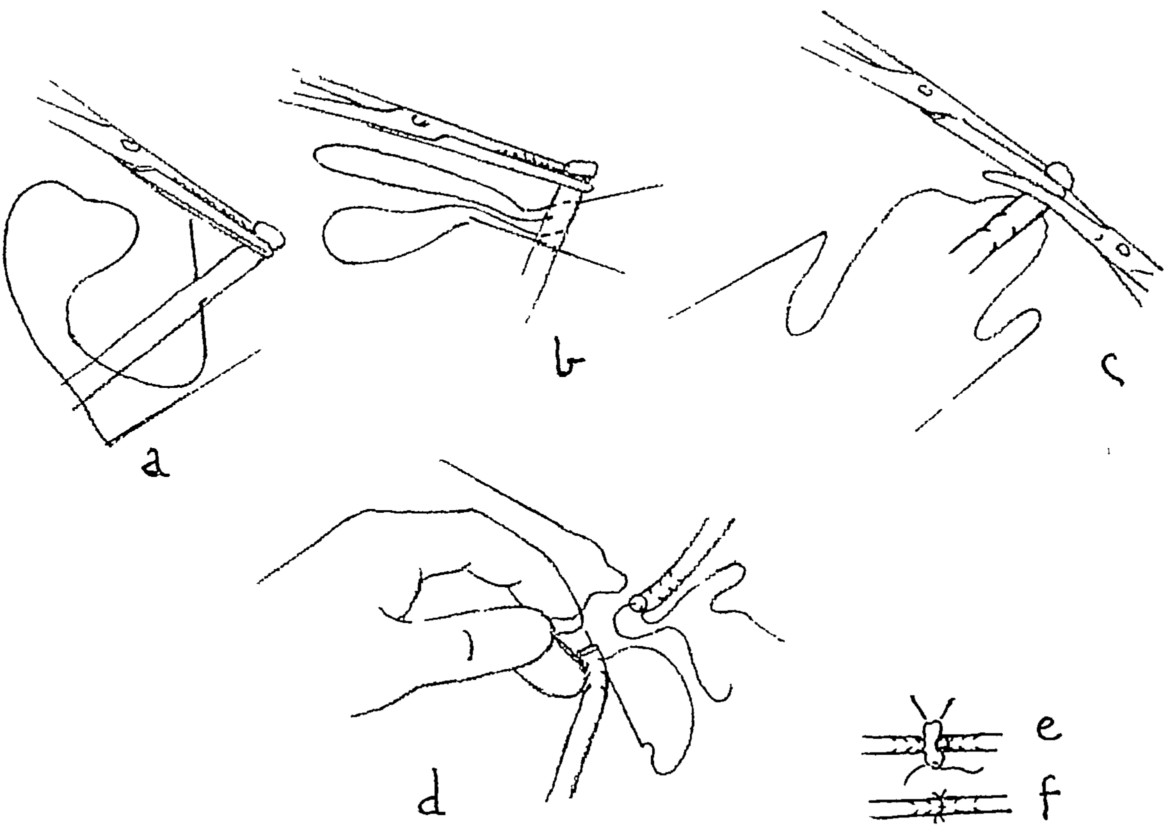


FIG 158 Bunnell's tenorrhaphy For details, see text

line of repair is covered with a layer of subcutaneous fat or fascia to prevent the formation of adhesions The wound is closed in layers in the usual manner and without drainage As mentioned previously, if the condition of the wound is such as to require drainage, primary tendon repair is contraindicated Finally, a molded splint is applied in such a manner as to immobilize the part without undue tension on the repaired tendon

Bunnell (15) employs the following technic (fig 158): "In suturing tendons silk should be used strong enough to allow early motion and it should be dipped in a solution of bichlorid of mercury to discourage bacterial growth The delicate epitenon covering the tendon should not be handled or adhesions will result The tendon is grasped at its tip with a Kocher hemostat and held under tension while the suture is

placed. An 8-inch piece of silk with a No 9 calyx-eyed cambric needle threaded on each end is used for each tendon end. The needles are passed diagonally back and forth through the tendon starting ½ inch form the end and working toward the end with two or three stitches on one side and three or four on the other finally to emerge on opposite sides ⅛ inch from the tendon end. The amount of silk showing on the surface is minimal, as each needle is reinserted only a few fibers away from where it emerged. With sharp scissors the tip of the tendon grasped by the hemostat is cut off. Each needle is then made to reenter the side of the tendon and emerge from its end. There is thus a non-strangling splicing effect over a length of tendon. In each tendon end to be joined the two strands of silk are then drawn tight to remove all slack and are tied with three knots each to the two silk threads emerging from the other tendon end and are cut off short. The knots are thus buried between the tendon ends which are

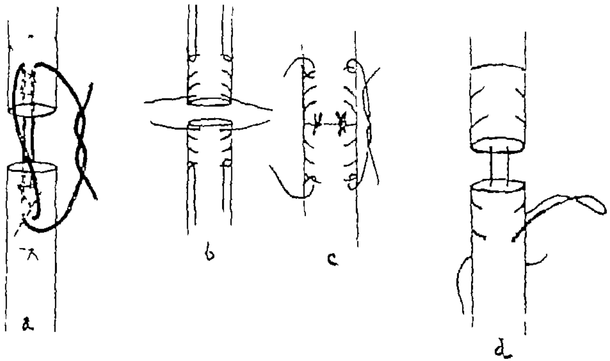


FIG 159 Various methods of suturing tendons a, Gratz. b–c Harmer d Frisch

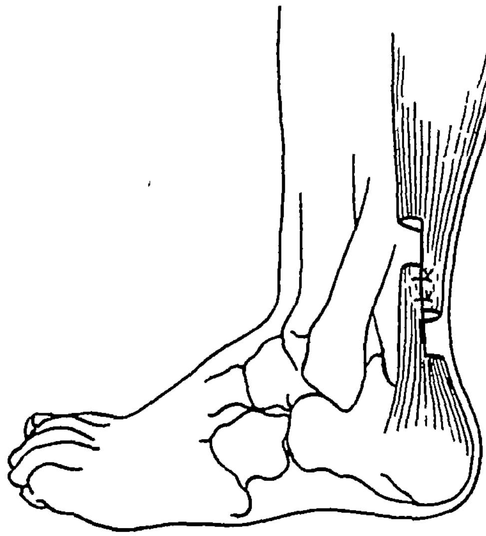
held in close approximation. A little rolling fits the ends accurately together. Such junctures later become invisible and in a few years the silk is absorbed.'

Other methods of suturing are illustrated in Figure 159. Generally speaking however they are unnecessary and are often harmful, inasmuch as they tend to prolong the operation, destroy more lymph channels, diminish the circulation, and owing to the greater amount of suture material required, delay repair.

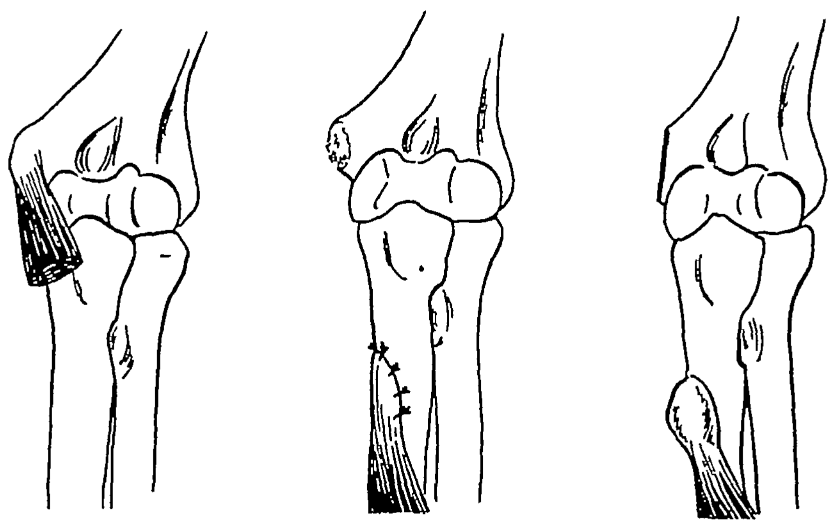
The postoperative management is of the utmost importance. There is a considerable difference of opinion as to the period necessary for immobilization. Some surgeons advise fixation for 10 to 14 days to prevent the tearing out of the sutures, accepting the danger of possible adhesions likely to arise from prolonged immobilization. On the other hand there are those who risk the hazard of torn sutures and advise that the tendon be moved throughout its entire range of motion from 24 to 36 hours after the introduction of the sutures. To obtain the most satisfactory results movement following the repair of tendons enclosed in synovial sheaths should be

started after a week, in the case of those without synovial membranes, it is best prolonged for another week, as the latter are not so apt to become adherent Massage, heat, and active motion are instituted as soon as immobilization is discontinued

Secondary Repair. Secondary tendon repair is undertaken only after all infection has ceased, the parts have been made soft and pliable by massage, and all overlying



I



II

FIG 160 Methods of lengthening tendons *I*, by Z-plastic, applicable only for tendo achillis, as in other locations remaining raw areas become adherent to surrounding tissues *II*, by muscle-stripping *a*, common flexor tendon attached to medial epicondyle *b*, tendon separated from epicondyle and sutured to periosteum of ulna (Page) *c*, epicondyle severed and sutured to periosteum of ulna (Bailey) (Rowlands and Turner)

scar tissue has been excised and replaced with healthy skin and subcutaneous tissue The incision should be so planned as not to lie directly over the affected tendon, and should be of ample length, extending well above and below the probable site of the injury, as the tendon ends are apt to be widely separated and the amount of scar tissue considerable When the tendon has been identified, the scar tissue is excised,

and if there is no extensive loss of tendon substance, the segments are pared and approximated. The gliding mechanism must be restored otherwise, subsequent adhesions will form and bind the line of union to surrounding parts, thus destroying the benefits of the operation. Such a mechanism is obtained by rolling around the line of union a free graft of the specialized fat taken from around the tendo achillis or triceps aponeurosis, or from above the fascia lata, and anchoring it to the tissues surrounding the tendon The use of foreign bodies, such as segments of veins, fascia, allantoic membrane, and silver foil, for this purpose has not proven successful.

If the tendon segments are so widely separated that they cannot be brought together, (1) the defect may be bridged by a graft. This is the most satisfactory procedure, and for details the reader is referred to Chapter II. (2) The proximal end of the divided tendon may be freshened and sutured into a neighboring sound tendon which has been split along its longitudinal axis to receive it. Or (3) the tendon may be lengthened by turning down a flap from the ends of one or both segments This plan is seldom practicable, except for the lengthening of the tendo achillis, since the exposed raw areas which remain eventually become adherent to the surrounding tissues and defeat the purpose of the reconstruction. The operation has been largely supplanted by muscle-stripping, a procedure whereby the muscle is separated from its bony attachment and reattached to the bone at a lower level (Fig 160) The technic of tendon lengthening is briefly as follows Beginning at a point far enough from the end to permit of the necessary lengthening, a horizontal incision is made through half the substance of the tendon. Here the knife is turned at right angles and drawn toward half the the end, splitting the tendon longitudinally until just enough remains to make a hinge. The opposite segment is treated similarly, and the free ends of the split tendons are rotated through an arc of 180 degrees and sutured together, raw surface to raw surface.

Nerve Wounds

Severed nerves, like tendons, are best repaired by primary suture when feasible, i.e., when the wound is aseptic and can be closed without drainage. If repair is delayed, the proximal end of the nerve retracts, the segments become bound down to adjacent structures by connective tissue, and the muscles become atrophied, stretched, and fibrotic—all of which increase the operative difficulties and lessen the prospects of favorable functional results. Direct end to-end suture is the choice procedure when possible, but experience has shown that even a technically successful suture does not guarantee complete recovery, inasmuch as the scar which inevitably forms at the line of union acts as an impenetrable barrier to nerve impulses. In any case, the return of function does not begin before 6 or 9 months, and in some instances not for a year or more following repair since nerves, unlike tendons, do not unite directly, before impulses can be transmitted, the peripheral segment must undergo Wallerian degeneration and the new neuraxons must descend from the proximal end.

If there is evidence to indicate that the nerve is damaged but not completely severed, as in the case of a contused wound, the problem is more difficult. Here the question arises whether to wait in the hope of spontaneous recovery or to operate immediately While early exploration permits of the direct application of tests to determine the viability of the nerve, frequently shortens the period of disability, and lessens the

amount of cicatricial changes in the muscle, these advantages must be weighed against the possible loss of the remaining function occasioned by the operative trauma Generally speaking, the expectant plan of treatment is preferable, as experience has demonstrated that spontaneous recovery occurs in 40 to 60 per cent of such cases Meanwhile, precautions must be taken to prevent atrophy and overstretching of the muscles supplied by the afferent nerve by the use of cock-up splints and the institution of physiotherapy, such as heat, massage, and electricity

If the wound is infected, all thoughts of primary repair must be abandoned and the operation deferred until healing has taken place As a precautionary measure against undue contraction and the formation of large neuromata, and to facilitate identification of the nerve ends, they are anchored together at the time of injury

Primary Repair. What has been said regarding gentleness and asepsis in tendon suture applies equally to nerve suture, since in both instances successful results depend upon a minimum of scar tissue formation The suture material to be employed is

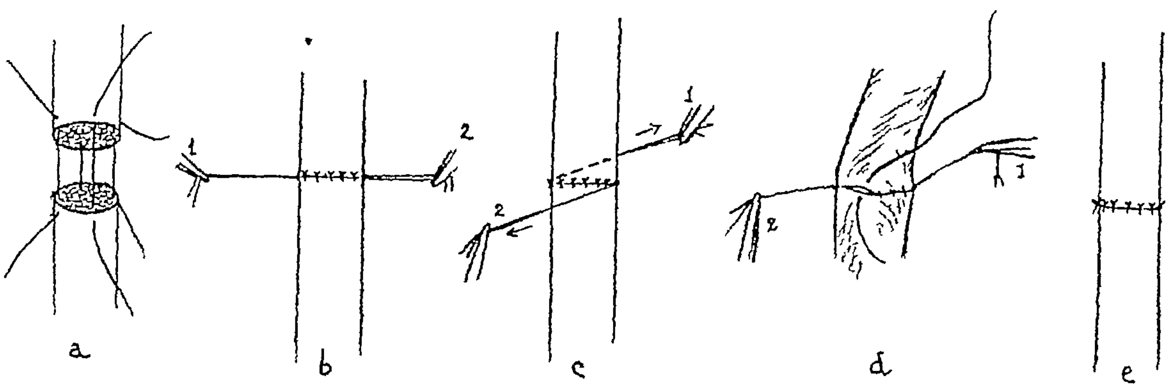


Fig 161 Primary nerve suture *a*, identification sutures placed at corresponding points in epineurium of proximal and distal segments Purpose of sutures is to mark out definite circumferential points upon nerve trunk, to facilitate original anatomic alinement *b*, identification sutures used as tractors while supplementary sutures are passed through epineurium of anterior surface of nerve, to prevent escape of neuraxons *c*, identification sutures used to rotate nerve, to expose posterior surface *d*, posterior surface sutured *e*, repair completed For details, see text (Koch and Mason)

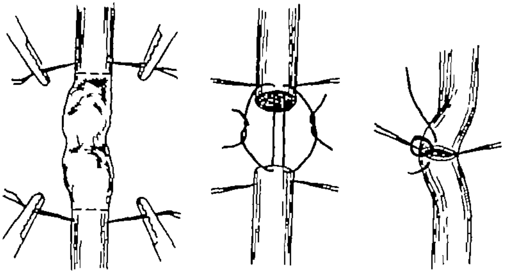
#00000 arterial silk or black corticelli silk separated into its component strands and passed through vaselin To maintain the normal intraneural pattern, every effort should be made to approximate the ends without rotation of the fasciculi, otherwise, a sensory proximal fasciculus may be united to a distal motor bundle, and should regeneration take place, sensory neurons from the proximal segment could not be expected to supply motor function to the tract below

The parts are draped in such a manner as to permit of the observation of muscle movements arising from the stimulation of the nerve trunk When the segments have been identified, 4 interrupted sutures are passed through the epineurium of both extremities at exactly corresponding points (fig 161) The frayed ends are then cut clean at right angles to the nerve by a single stroke of a razor blade, and the previously passed sutures tied in such a way as to avoid buckling of or tension on the nerve ends Accessory sutures are then placed in the nerve sheath, so that the axones will not escape between the sutures The suture line is protected by burying it in a bed of normal muscle, or if this is not practicable, it may be covered with a flap of fat from the vicinity (48, 31, 67, 58) The wound is then accurately closed in layers and a

pressure dressing applied. If a tourniquet has been used, it is removed and the part splinted in such a position as to exert a minimum of tension on the suture line. Post operatively, the nutrition of the affected muscles is preserved by daily massage. As soon as the muscle begins to respond to the faradic current, voluntary movement is instituted.

Secondary Repair If the damaged nerve is to be repaired by means of a secondary suture, the skin is carefully prepared, a tourniquet applied, and the part draped in the customary manner Through an arched incision in the skin over the course of the affected nerve the muscles are separated along their cleavage planes until the nerve comes into view It is then freed above and below the injury and all contiguous scar tissue is sharply dissected away

The treatment of the nerve itself will depend upon the existing conditions If it is still intact and is being pressed upon by a foreign body or a cicatrix, the removal of



a b c

FIG 162. Secondary repair of nerve *a*, identification sutures placed at corresponding points in nerve sheath of proximal and distal segments before normal position has been disturbed by dissection. These sutures placed far enough above and below lesion to assure normal anatomic landmarks. Scar tissue resected serially with razor blade held in forceps in sections about 1 mm. thick, until normal nerve bundles present. (See Figure 105) *b* identification sutures used as tractors while supplementary sutures are passed through epineurium of anterior surface of nerve. *c* nerve rotated with aid of identification sutures, to expose posterior surface for suturing

the compressing agent may be all that is necessary to restore its physiologic continuity But where compression has existed for a long time or the axis cylinder has undergone degeneration, a satisfactory functional result is not to be expected even after neurolysis. If the nerve has been partly severed and nerve fibers still remain between the segments, a decision must be made between (1) leaving the cicatricial bands that join the two ends and freeing the nerve above and below and (2) excising the scar tissue and making an end-to-end anastomosis If the nerve has been completely severed and the ends can be approximated directly without tension, the neuroma which has formed at the proximal end of the divided nerve is sliced progressively until the nerve bundles pout and the distal end is freshened. End-to-end approximation is then carried out in the usual manner (fig 162)

If after removal of the cicatricial tissue the defect is found to be too great for direct

end-to-end anastomosis, it may still be possible to bring both ends together (1) by extending the mobilization of the proximal and distal portions of the nerve, (2) by rerouting the nerve along a shorter course, (3) by placing the part in a more favorable posture, so as to shorten the distance to be overcome, or (4) by gradually lengthening the nerve Babcock (3) employs the latter procedure in a 2-stage operation as follows. The nerve is exposed and the part flexed, so as to bring the ends as close together as possible The fibrous portions of the distal and proximal segments are overlapped and sutured firmly together The wound is then closed and the part immobilized in a cast for several weeks, after which the joint is gradually extended until there is a normal range of movement At a second operation 1 to 2 months later, when the nerve will have stretched sufficiently to permit of an approximation of the segments, the scar tissue is removed, and a direct end-to-end anastomosis is carried out in the usual manner.

If the above measures are inadequate, recourse must be had to nerve grafting (p 191). The use of foreign bodies, nerve flaps, fascia lata, veins, etc , for bridging the defect is merely of historical interest, as these materials have no practical value

Artery Wounds

Artery wounds vary in extent from contusions of the walls to partial or complete section In contused wounds the small vessels bear the brunt of the force, but the larger vessels, if healthy, usually escape damage by reason of their mobility and elasticity which permits them either to absorb the force or to slip away from the point of impact A diseased vessel, on the other hand, when subjected to the same degree of force, is likely to become damaged because of its friability Hemorrhage is apt to be less severe from a lacerated wound than from one which is cleanly incised, since in the former case the tunica media and intima are torn at a higher level than the adventitia, and their contraction and retraction within the outer coat occlude the vessel Lateral wounds may lie at any angle to the course of the vessel Those in the long axis gape little and occasion only slight bleeding, but transverse wounds separate widely and may give rise to more profuse bleeding than that from a wholly severed vessel, inasmuch as complete retraction is prevented by the remaining intact segment

Treatment

The measures employed to bring about temporary hemostasis are discussed in Chapter I Permanent control of bleeding is undertaken only after the wound has been thoroughly cleansed and the field cleared of extravasated blood The technic to be adopted will depend upon the size and importance of the blood vessel If a medium-sized vessel is ruptured, it is ligated, both proximal and distal ends being tied at the point of injury. The proximal end can usually be found without difficulty owing to its pulsation and free hemorrhage, but the distal end is often hard to locate because of its tendency to retract into the tissues Nevertheless, it should be sought and ligated, otherwise, serious hemorrhage may occur when collateral circulation has become established If a main trunk, such as the common carotid, femoral, or popliteal, is involved, repair by suture is the ideal procedure

Repair by Suture For a *longitudinal wound* Dorrance's (29) method is applicable (fig 163). "The clamps are applied 2 5 cm above and below the cut The suture is

started 1.5 mm. above the cut edge, the suture is passed through the outer two coats and tied, the end of the suture is grasped by a haemostat, the needle is next passed through all the coats of the artery on both sides 1.5 mm. below the first suture and 1.5 mm. from the cut edge, the suture from now on is a continuous mattress with the dropping back one-half a suture length every third suture until the end of the incision is reached then the suture is passed through the outer two coats 1.5 mm. below the lower end of the cut and a half hitch made to tie the suture. The same suture is continued as a whip-stitch over the edges of the artery outside of the mattress suture until the starting-point is reached, when the two ends of the suture are tied. The artery is grasped in a gauze pad, the distal clamp removed, then the proximal clamp and the artery is dropped back in place and the deep fascia sutured around the line of approxi-

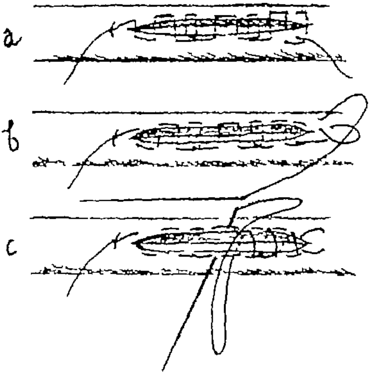


FIG. 163 Dorrance's method of suturing longitudinal arterial wound. For details, see text

mation. The method of suturing an oblique cut is practically the same as the longitudinal."

To repair a *transverse incision half way through the artery* Dorrance applies the clamps as before. "The suture is started 1.5 mm. from the lateral end of the cut and passed through the outer two coats and tied the end of the suture is grasped with a haemostat. The suture is continued as a continuous-mattress suture, dropping back one-half a suture every third stitch until the opposite end of the cut is reached, then the suture is passed through the outer two coats and a half hitch made to tie the suture the same suture is continued back over the line of suture as an over-hand whip-stitch outside the mattress suture until the starting point is reached, when the two ends are tied. The mattress suture should be 1.5 mm. from the cut edges at all times. The deep fascia should be sutured around the line of approximation."

End-to-end Anastomosis In cases where *the vessel is completely severed* an end to-end anastomosis may be performed, provided the vessel is not contused or lacerated for

more than 2 cm of its length, and the wound is aseptic and can be closed without drainage The technic elaborated by Carrel and Guthrie (18) has made arteriorrhaphy a relatively safe and frequently satisfactory procedure The operation depends for its success upon an aseptic and atraumatic technic and the prevention of clotting within the lumen of the vessel This is effected by the use of fine paraffined silk on fine round needles and by bringing the intima of both segments into accurate apposition in a position of eversion, so that at the completion of the operation a continuous surface of vascular endothelium will line the lumen

In addition to the usual instruments employed in wound surgery, the following are required for the repair of arteries several small sharp round arterial needles # 15 or # 16, mosquito forceps, curved and straight-eye forceps, clamps for the occlusion of the artery (preferably those of Crile), curved and straight cuticle scissors, an eye-dropper, a sharp cataract knife, and # 00000 paraffined silk

The affected vessel, having been exposed, is cleared above and below the injury for a distance sufficient to permit of the application of clamps The clamps are applied in such a manner as not to damage the arterial wall and should be removed as soon as the suturing is completed The blood in the segments between the clamps is expressed, the ends of the vessel are irrigated with citrate solution, and a drop of paraffin oil is introduced with an eye-dropper If the ends of the vessel are uneven, they are incised to form straight edges The adventitia is stripped back, and 3 sutures are passed through the other coats at equidistant points, (fig 164) so that when they are pulled upon, the circumference of the vessel will take the form of a triangle These sutures not only facilitate the balance of the approximation, but also serve to bring the intima of both segments into apposition Two of the traction sutures are held taut, and the edges of the vessel between them are approximated in a straight line The manoeuver is repeated until each of the 3 segments of the circumference have been closed The clamps are then removed and the suture line kept under observation for several minutes If blood oozes from the vessel, the outer coat is folded over the bleeding point by means of a Lembert suture

Markowitz' (78) description of the details of Carrel's technic of arterial anastomosis cannot be improved upon (fig 165) "Two rubber shod serrefines are applied to the artery two inches apart The adventitia is carefully stripped from the part to be sectioned by means of the modified cilia forceps and cuticle scissors This step justifies a little care " The adventitia should not be stripped back too far, since this coat furnishes the nutrition to the vessel. With a sharp knife the vessel is sectioned midway between the clamps "Each segment is rinsed with normal saline from a blunt tipped eye dropper This serves to remove any traces of blood A little paraffin oil is similarly introduced The next stage is to remove any traces of adventitia from the immediate proximity of the cut edge This is best done by attempting to pull the adventitia over the edge with the cilia forceps and cutting it with fine cuticle scissors As the adventitia retracts, it leaves a small strip of blood vessel completely denuded of this coat so that when the sutures are passed, particles of adventitia cannot become entangled in the thread and be brought into the lumen The two vessels are now opposed by three guy sutures placed as illustrated This is the essential step in the procedure of uniting the transected ends The dependent guy suture is suitably weighted with a mosquito forcep, so that the bottom row is not included in the process

of suturing It may be more convenient for the assistant to exert gentle traction on the dependent guy thread than to weight it with a forcep However it may be accomplished, the triangular method of blood vessel anastomosis is valueless unless a sufficient pull is exerted on each of the three guy threads during the suturing The first guy suture is inserted in an inward direction in the blood vessel and in an outward direction in the other, corresponding points being chosen, that is, care should be taken in

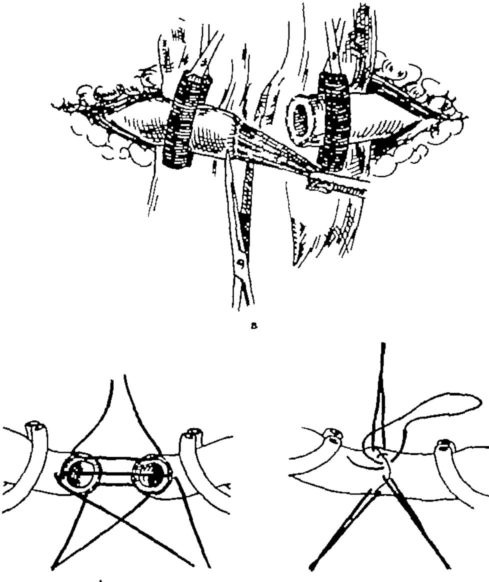


FIG. 164. Arterial end-to-end anastomosis *a* ends of vessel clamped, adventitia drawn over and cut with scissors. *b* three equidistant guy sutures passed to facilitate suturing *c* ends approximated with aid of guy sutures (Printy)

laying the sutures to evert the edges. Each guy suture is tied as placed, and the needles are left attached.

"The assistant places his right forefinger on the dependent guy thread. With the left hand, he exerts gentle traction on the guy thread closest to him, leaving the needle free for the surgeon to use. The surgeon picks up this needle in a mosquito forcep and exerting traction with his left hand on the remaining guy thread, rapidly sews one side of the triangle with over and over sutures about one millimeter apart. He sews

toward the guy suture which his left hand is holding When he gets to the corner of the triangle, a tie is made to this guy suture The triangle is now rotated in this fashion the guy suture held by the assistant's left hand is made dependent, and brought taut with the right forefinger The surgeon takes the dependent thread and hands his guy thread to the assistant's left hand These maneuvers take but a few seconds, following which another side of the triangle is sewn to the original needle

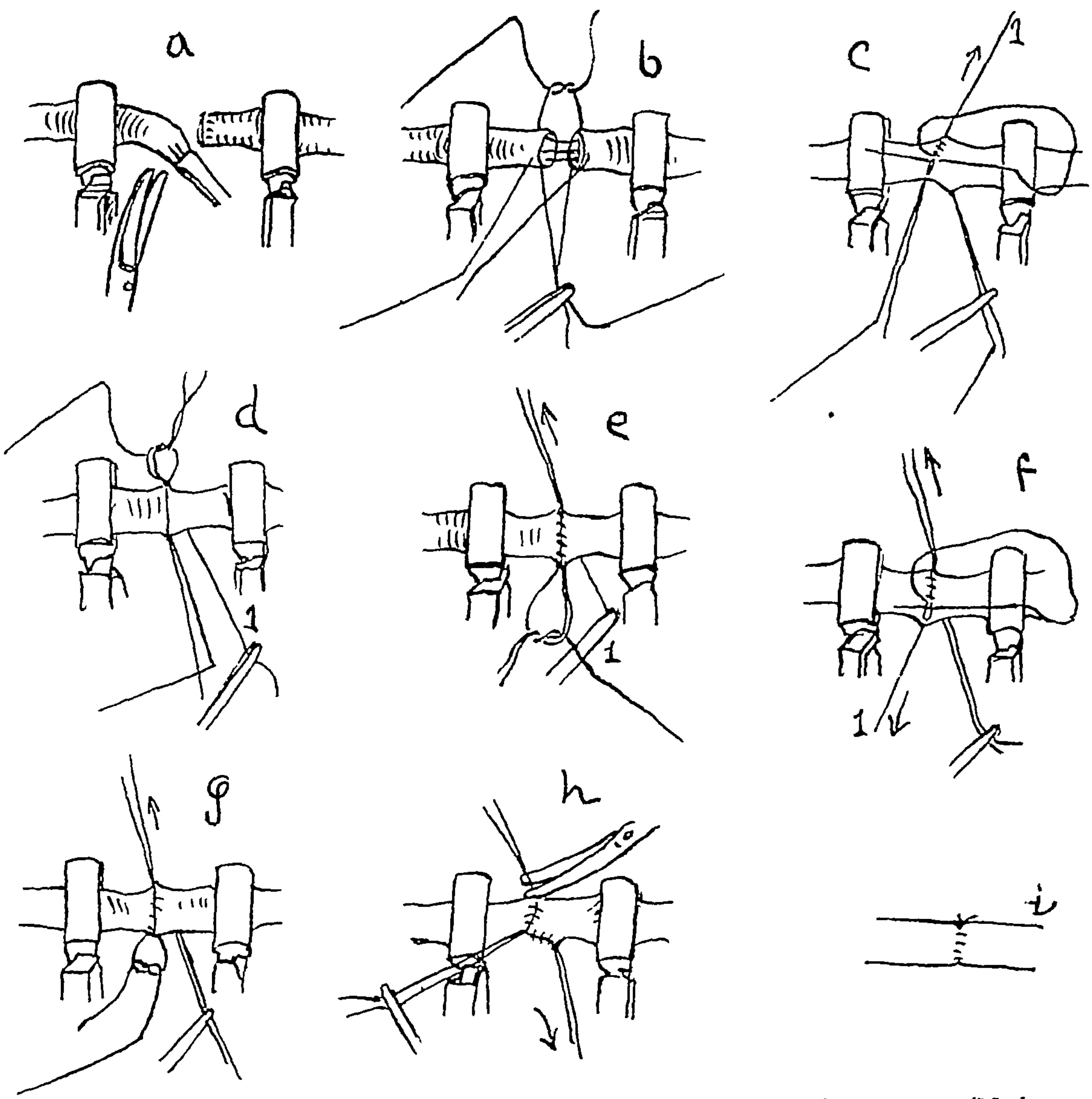


FIG 165 Carrel's technic of end-to-end arterial anastomosis For details, see text (Markowitz Experimental Surgery)

"The whole vessel is now rotated in an opposite direction, through an arc of 240 degrees so that the remaining incompleted side is brought uppermost into a suitable position for suturing When this has been sutured the guy threads are cut and the bulldog forcep on the cardiac side of the junction is slowly released At first, there may be a slight leakage of blood, which does not last more than a few seconds, in which case, the other forcep is also removed If the suturing has been uneven . it may be necessary to place one or more interrupted sutures to stop hemorrhage

"The operation should take no more than 20 minutes. At intervals the vessels are moistened with liquid paraffin"

If an end to-end anastomosis would be impracticable because of too great a destruction in the length of the vessel, it is occasionally possible to maintain the circulation temporarily by means of a graft taken from the saphenous vein or by the use of Tuffier's paraffined silver tube. The circulation will continue for several days before thrombosis occurs, by which time collateral circulation may have become established. If a Tuffier's tube is employed it is removed at the end of 4 days.

Grafting Partial defects of large arteries may be patched with fascial grafts. After exposure of the artery, the circulation in the area about to be grafted is obstructed by the application of rubber-sheathed clamps. The interior of the vessel is washed out with a citrate solution and smeared with sterile vaselin. The exact dimensions of the defect are obtained by means of sterile calipers. An appropriately sized section of fascia lata is removed, its smooth surface smeared with vaselin, turned over the defect, and anchored in position by means of 4 equidistant sutures. The edges of the graft are then fixed to the vessel wall with a continuous suture of fine silk. The clamps are gradually removed and the overlying wound closed.

Fractures

Fractures should be splinted as soon as possible after injury and preferably before the patient is transported from the scene of the accident, in order that further displacement of the fragments and injury to the surrounding soft parts may be prevented. Reduction is best carried out before swelling and muscle contraction set in, since the congestion and muscle spasm consequent upon delay increase the difficulty of manipulation. X ray examination is a valuable aid to diagnosis, but if the proper facilities are not immediately available, reduction should not be postponed on that account. After the fragments have been reduced, any wounds in the adjacent soft parts are treated in accordance with general principles. As a rule, however, primary closure should be avoided. All compound fractures call for the administration of tetanus antitoxin and, where there is much contusion of muscle, antigas bacillus serum The management of special fractures will be discussed in the respective sections.

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CHAPTER IV

BURNS

A burn is a type of wound caused by thermal, chemical, or electrical heat, or by radiant energy Thermic burns arise either from direct exposure to flame or from contact with hot liquids or steam in which case they are referred to as scalds In the case of fire-burns the hair is scorched and the destruction is apt to be deeper and more circumscribed. In scalds, on the other hand, the hair is unaffected but may fall out subsequently, the burn is more diffuse and tissue destruction more superficial, owing to the rapid cooling of the liquid. Common sources of burns are gas explosions, the flash which results from short-circuiting of electric wires, and contact with molten metals, hot oil, and inflammable liquids.

Fortunately, during the past twenty years the number of injuries resulting from burns has decreased, due to the safer heating and lighting conditions of our day, and of preventive legislation and public education on the subject. The mortality rate has also been materially reduced, owing to the greater emphasis placed on supportive measures for the relief of the associated constitutional phenomena, the greater attention to the prevention of infection and the improved methods for the care of the burn itself Nevertheless, the rate is still too high owing to a lack of complete understanding of the pathologic phenomena involved. Statistics show that in the United States in 1937 approximately 7 000 lives were lost as a result of burns (57), 45 per cent occurring in children under 6 years of age.

CLASSIFICATION

From the standpoint of prognosis and treatment, the most convenient classification of burns is that suggested by Dupuytren (29) based upon the depth of the tissue destroyed (fig 166) *First degree.* A first degree burn results from exposure to a temperature of 140°F and is marked by swelling redness, and tenderness of the skin, due to a dilatation of the blood vessels. There is no actual destruction of the epidermis and no vesicle formation and although the epithelium may peel off in strips, scarring and pigmentation are absent. Repeated exposure of the part however, may sometimes lead to a patchy pigmentation *Second degree* A second degree burn is due to exposure to a temperature of 160 to 210°F and is characterized by a destruction of the epidermis without involvement of the underlying dermis. It is manifested by all the local signs of inflammation and by the formation of vesicles filled with a clear limpid fluid which on rupture expose a shiny uninjured dermis. As in the case of first degree burns, healing takes place without scarring *Third degree* A third degree burn is one in which both the epidermis and the upper layers of the dermis are destroyed. The bases of the papillae remain intact and can be seen as red dots on the surface. The deeply embedded skin glands and hair follicles likewise escape damage. Since

the terminal nerve filaments are left exposed, this is necessarily the most painful type of burn As healing progresses, an eschar is formed which is at first gray but later turns black and finally separates, leaving a granulating surface Gradually the area becomes covered with a thin superficial scar with little tendency to contract, owing to the preservation of the papillae, skin glands, and hair follicles which serve as a source of epithelium for the raw area In burns of second and third degree the size of the defect will have no bearing on the length of time required for healing, due to the survival of scattered islands of epithelium from which this process can take place *Fourth degree* A fourth degree burn is due to prolonged exposure of the part to a temperature of 210°F or more and involves the destruction of the entire integument. The burned structures ultimately separate with or without suppuration, leaving a mass of granulation tissue Owing to the loss of all the epithelial elements, the raw area can be covered only by an epithelial proliferation from the wound edges or by a drawing in of the adjacent tissues, and as a result scarring and deformity are

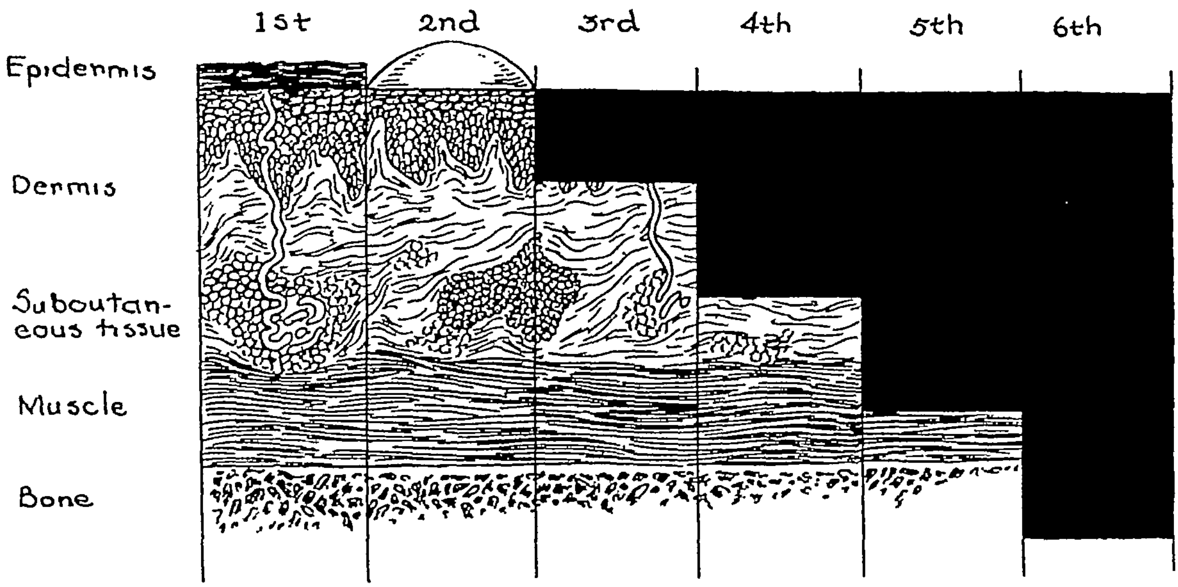


FIG 166 Degrees of burns First Degree, erythema, Second Degree, vesiculation, Third Degree, destruction of epidermis, Fourth Degree, destruction of dermis, Fifth Degree, destruction of subcutaneous tissues, Sixth Degree, carbonization of all structures For details, see text (Dupuytren)

extensive and keloid formation is common In burns of this type the length of time required for healing is in direct proportion to the size of the defect Blair (15) states "For instance as a rather loose estimate, say that a defect 2 inches in its least diameter might require four weeks for complete healing, then the spontaneous healing time for a similar wound from a burn 4 inches in diameter might be 16 weeks, while one of a 12 inch diameter might not heal in 144 weeks" *Fifth degree* This type of burn involves the loss of both the subcutaneous tissues and the skin *Sixth degree* Sixth degree burns imply a total destruction and carbonization of the tissues

GENERAL MANIFESTATIONS

Superficial burns involving less than 10 per cent of the body surface give rise to no constitutional reaction More severe burns, however, are accompanied by more or less definite general disturbances, and it is these latter which cause the greatest

amount of anxiety For the sake of convenience they will here be taken up in stages. Although a sharp differentiation between the various stages is impossible because of their variety and tendency to overlap, nevertheless this plan of description best illustrates the clinical picture.

(1) Stage of Initial Shock

The majority of victims of severe burns suffer from some degree of neurogenic shock due to the fright and pain occasioned by the accident and the nociceptive impulses induced in the damaged sensory nerve endings. Another contributing factor may be the carbon monoxid asphyxiation caused by the inhalation of smoke. More recently it has been suggested that primary shock in burns is due to either an increase or a decrease in the activity of the adrenals. Harkins (38) summarizes the studies of Freeman (34) and Freeman, Shaw, and Snyder (35) who 'have proposed a theory of shock that consists in essentially an overexcretion of adrenalin to keep the blood pressure near normal despite a lowered blood volume. If the blood volume decreases more, and this it tends to do because of capillary exudation with increased arteriolar resistance, the increased adrenal output can keep the blood pressure compensated only so long and then it collapses. Saito (72), on the other hand, expresses the belief that the shock is due to a deficiency of adrenalin, and alleges in proof that he has been able to prolong the life of experimentally burned animals by means of adrenalin injections.

The symptoms of primary shock following burns do not differ from those following neurogenic shock due to other causes (p 383) The condition is rarely serious, never prolonged and responds to the administration of sedatives and the application of warmth. Wilson found that only 2.5 per cent of patients suffering from burns died in this stage. When the burn involves considerable surface area and depth however, the primary shock may merge into secondary shock and once this stage has been reached, the outcome is less favorable

(2) Stage of Secondary Shock and Primary Toxemia

Secondary shock and primary toxemia will be discussed together, since both conditions are probably due to the same causes, and their symptoms overlap to such an extent that it is difficult if not impossible to assign each to its proper source. Secondary shock supervenes 3 to 4 hours after the infliction of the burn either as a continuation of the initial shock or as a primary manifestation. Its incidence and intensity are governed more by the amount of surface area involved than by the depth of the wound and, unlike the initial shock it will not respond to treatment. Acute toxemia sets in later than secondary shock, usually about 12 hours after the injury, although it may be delayed for 50 hours Unlike shock, it bears a closer relationship to the depth of the burn than to the surface area involved. It has been estimated that about 80 per cent of deaths occur during this stage, the greatest danger to life being reached at the end of 48 hours.

The symptoms vary in degree from slight malaise to severe toxemia and include vomiting diarrhea, incontinence of urine and feces, chills, elevation of temperature, rapid and feeble pulse, and low blood pressure. The urine is scanty and contains albumin, casts and blood. Nervous symptoms are common, such as apathy list

lessness, or irritability, and in severe cases delirium, convulsions, coma, and even death may ensue

Mechanism An understanding of the mechanism underlying this stage is important if treatment is to be effective, but unfortunately, despite extensive laboratory and clinical research, a completely satisfactory explanation has not as yet been evolved The constitutional disturbances have been variously attributed to the following factors, none of which can be ignored, since each finds support in some actual observation

(a) *Interference with Normal Function of Skin* According to this hypothesis, the symptoms are induced by an interference with the excretory and thermotactic function of the skin, but this explanation is not sufficient to account for the constitutional phenomena and has therefore been generally discarded

(b) *Toxemia* According to this view, the constitutional phenomena are to be attributed to the absorption of toxic agents generated at the site of the burn (6, 26, 97, 98, 69) Robertson and Boyd (69) conclude that. "From a purely clinical point of view, there seems to be no doubt that the burned tissues are responsible for the production of some toxin which is taken up by the blood stream" A number of different substances have been held responsible It is interesting to note that Fender (33) enumerates 17 toxins suggested by 34 different writers Robertson and Boyd (69) believe the toxins to be of the nature of primary and secondary proteoses, while Pfeiffer (66) considers them to be nucleoproteins, Parascandolo (65) classes them with ptomains Others assume that they are histaminlike in character, due to the fall in blood pressure which they occasion The protagonists of the toxemic theory (95) claim that alcoholic extracts of burned skin are toxic, and that if the burned area is excised within 8 hours after the injury, toxemic symptoms will not develop, if, moreover, the burned skin is grafted on normal animals, toxic symptoms will result Although this theory is provocative of much thought and strengthened by the fact that autopsies show degenerative changes of a toxic nature in the liver, kidney, spleen, adrenals, bone marrow, and lymphoid tissue, nevertheless it is inconclusive, in that no specific proteolytic toxin, either from the burned area or from the circulating blood, has as yet been satisfactorily identified or isolated Underhill and Kapsinow (87) demonstrated that the toxic symptoms were due to the alcohol in the extract rather than the burned skin and were able to produce identical symptoms after the injection of alcoholic extracts of normal skin They further proved that the rate of absorption from burned areas was delayed, and concluded that. "Our experience with burns leads us to doubt the existence of a 'burn toxin,' and to believe that the persistence of this viewpoint is an obstruction in the way of clarification of the burn problem" Recently, however, Mason, Paxton, and Shoemaker (55) have shown experimentally that potassium iodid is absorbed as readily from burned areas as from normal tissue Harkins (38), opposing the toxemic theory, summarized the results of tests as follows. "(1) The transplantation of burned skin had no effect on the recipient animal (2) The effects of débridement on the survival period of burned dogs the survival averaged seven and one-half hours in the débrided series and seventeen and one-half hours in the control dogs (3) Transfusion of blood from burned to normal animals was without effect"

(c) *Loss of Fluid* The advocates of this theory believe that the constitutional disturbances are brought about by the escape of large quantities of plasma into and from the burned area (8, 37) The first to draw attention to the extensive fluid loss

accompanying burns was Underhill (80, 87) It is estimated that in the case of a burn involving ⅓ of the body surface the loss of fluid during 24 hours may amount to as much as 70 per cent of the blood volume. In extensive burns this fluid loss results in a diminished cardiac output, a decreased blood pressure, and a lowered temperature. Serious changes also occur in the composition and chemistry of the blood. It becomes concentrated, and its increased viscosity impairs its circulatory efficiency, diminishes its oxygen-carrying capacity, and suppresses urinary secretion McClure and Allen (58) believe this concentration to be an index to the patient's general condition and state that "a blood concentration of 125 per cent is indicative of a dangerous condition and that one of 140 per cent is a condition which is not for long compatible with life." The red blood cells are increased in number, and the hemoglobin content may be as high as 145 to 200 per cent (47, 85) The leukocytes are also increased and may reach to from 20 000 to 25,000 per cu.mm. Locke (48) claims that when the erythrocytes number more than 9 000,000 per cu.mm. the burn is likely to end fatally Blood chlorids are diminished in proportion to the amount of tissue destruction (24) and in severe cases may be reduced as low as 50 per cent (85) Since this reduction is not accompanied by a correspondingly increased chlorin excretion from the kidney, it must be assumed that there is a retention of sodium chlorid in the tissues similar to that observed in pneumonia (24) Baur and Boron (7) found that the blood chlorids remained at a low level in the presence of slough and that they rose as soon as the devitalized tissue was detached

While it is true that extensive extravasation may occur soon after the infliction of a burn, dehydration cannot entirely explain the clinical manifestations, since the administration of fluids and attention to blood chemistry though affording initial relief, do not prevent death in the later stages (1) Furthermore, constitutional phenomena frequently occur in the absence of serious fluid loss (95, 97)

(d) *Bacterial Infection* There is some justification for the belief that infection plays a part in the production of the primary toxemia associated with burns, and many bacteria have been held responsible for the condition. Among the advocates of the theory of bacterial infection are Aldrich and Firor Aldrich (3) states "I am certain. that the conception of a burn as an infected surgical lesion is correct, and that it is infection rather than absorption of a split protein which causes death in burns. For, let me add again where there is no infection, there is no toxemia.' He believes (1) that the hemolytic streptococcus is the principal causative organism

(3) Stage of Septic Toxemia

The stage of septic toxemia is usually associated with deep burns in which, even if the patient recovers from the primary toxemia, there is still the danger of septic infection from the burned area. This stage manifests itself 5 to 7 days following the injury, although Aldrich declares that it may occur as early as within 24 hours The organism most commonly responsible is the streptococcus hemolyticus. The general symptoms are similar to those present in any bacterial intoxication. Locally the condition is evidenced by a cellulitis. The coagulum becomes sodden and loosened and is carried away by a thick, purulent, offensive discharge. According to Wilson, 15 per cent of the deaths resulting from burns occur during this stage.

PROGNOSIS

The lethal factors involved in burns are shock, toxemia, and sepsis, the incidence and severity of which depend upon (1) the extent and location of the burn, (2) the age of the patient, and (3) the interval of time between the infliction of the burn and the treatment

Other things being equal, the *extent* of the surface area affected has a greater bearing on the final outcome than the depth of the destruction. Thus scalds, even though

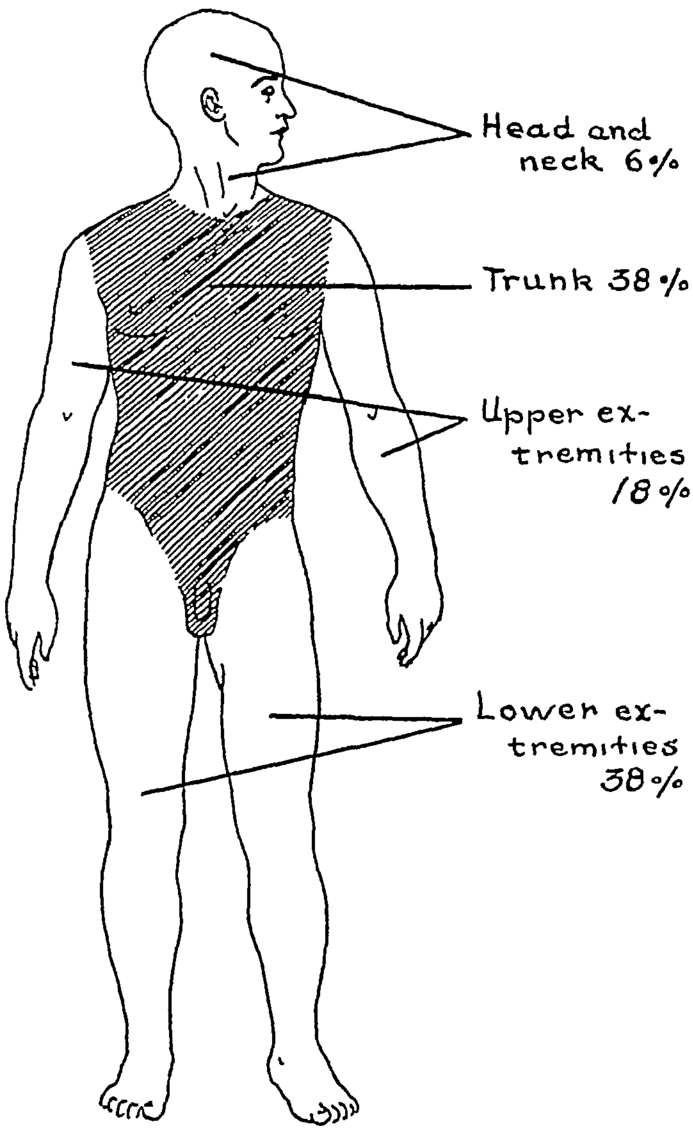


FIG 167. Evaluation of surface area of body (Berkow)

superficial, are associated with a high mortality, as the area they involve is usually considerable As a rule, first degree burns are fatal if from ½ to ⅔ of the body surface has been injured Deeper burns of corresponding extent are proportionally more serious, and the patient is apt to succumb if only ⅓ of the body surface is involved (31)

To evaluate the extent of surface involvement in the case of adults Berkow (9) divides the body as follows (fig 167)

Lower extremities including buttocks	38 per cent of entire body
Trunk including neck	38 per cent of entire body

Upper extremities	18 per cent of entire body
Head	6 per cent of entire body
Hand	$\frac{1}{4}$ surface of upper extremity
Arm and forearm	$\frac{3}{4}$ surface of upper extremity
Foot	$\frac{1}{6}$ surface of lower extremity
Leg	$\frac{1}{3}$ surface of lower extremity
Thigh	$\frac{1}{2}$ surface of lower extremity

MacCollum (51) states that in children "the head is relatively larger than it is in the adult. To compute this, the age of the child in years is subtracted from twelve. This figure is then added to the figure expressing the adult estimation, which is 6 per cent. The lower extremities are relatively smaller in a child. To compute this the age in years is subtracted from twelve and this figure subtracted from the estimation of the lower extremities of the adult which is 38 per cent."

As to the *location* of the burn, Pack (63) summarizes the prognosis as follows "Burns of the scalp are peculiarly susceptible to erysipelatous inflammation, but are not so often followed by cerebral mischief as one would think. When the burn is limited to the extremities or to the back, where the thick dorsal muscles serve as effectual protection to the subjacent viscera, the outcome is encouraging However, burns of the abdomen, with the dangerous visceral proximity, have the highest mortality Burns of the genitalia, the anterior thoracic surface and the face (over the area of trigeminal distribution) cause symptoms and dangers far out of proportion to their area allotment. Mucous membrane involvement, especially of the pharynx and larynx, add to the gravity of the case. Burns of the flexor surfaces are more serious than on the extensor surface."

The *age* of the patient is also to be considered in the prognosis. Burns are more apt to end fatally in children because of their unstable physiologic processes, their smaller stature, and their inability to protect themselves against the causal agent In a child a second degree burn involving $\frac{1}{10}$ of the body surface is considered serious, while one affecting $\frac{1}{3}$ may cause death.

The effect on prognosis of the *time interval between the infliction of the burn and the institution of treatment* is the same as applies to wounds in general and is discussed on page 265

MANAGEMENT

The management of severe burns will be considered under the two heads of *prevention and treatment of systemic reactions* and *care of the local lesion*

Prevention and Treatment of Systemic Reactions

The general treatment is directed toward (1) relief of pain, (2) relief of shock, and (3) replacement of the fluid loss.

When shock is profound, *pain* is comparatively slight, but in the absence of shock it is agonizing, and measures should be taken to relieve it at the earliest possible moment, as otherwise its intensity alone may precipitate shock. Adults are given morphin 0.016 gram ($\frac{1}{4}$ grain) and children tinctura opii 0 13 cc. (2 minims) for each year of age.

Since *shock*, if present, is an immediate menace to life, its relief takes priority over

the local treatment The management differs in no essential from that followed in the case of shock resulting from other causes (p 386) It is generally admitted that rest, heat, sedatives, and fluids are all that is necessary to assist the natural tendency toward recovery. The patient is undressed with a minimum of disturbance and exposure, his clothing being preferably cut away, or, in severe cases, left on until after he has partially recovered However, should the clothes be smoldering or impregnated with chemical agents, they should be soaked off in a tepid tub bath He is then placed in a warm bed, the foot of which is raised 30 cm to induce a better blood supply to the medullary centers If the location of the burn permits, he is made to assume the lateral prone position, the head being turned to one side This will facilitate his breathing, and, in case of vomiting, he is less apt to aspirate the vomitus The burned area is covered with a sterile dressing to prevent further contamination and all other local measures are deferred until the patient's general condition has improved, since local interference at this time is likely to accentuate the shock already present Such postponement entails little risk, as toxic absorption and infection do not occur for several hours after the infliction of the burn The body heat is maintained by means of warm blankets and the external application of heat in the form of hot-water bottles, electrically heated tents, hot drinks, and hot retention enemas of 10 per cent glucose at 2-hour intervals Some suggest the immersion of the patient in a warm bath of 5 per cent sodium bicarbonate or tannic acid at a temperature of 100° F This not only combats shock by maintaining the body temperature but also assists in soaking off the charred clothing and cleansing the wound The low blood pressure is counteracted by the use of parenteral fluids and stimulants (p 338) If there has been considerable hemorrhage from erosion of a blood vessel, the injection of 250 cc of properly matched citrated blood is indicated In the absence of a suitable donor, the intravenous administration of 200 to 500 cc of a 6 per cent gum acacia solution may be substituted

When the circumstances of the accident suggest the possibility of infection with the tetanus or gas gangrene bacillus—for example, in the case of burns sustained out of doors—antisera should be given in the manner described on page 268 As most burns sooner or later become infected with the streptococcus hemolyticus, the use of sulfanilamid (p 280) would seem advisable It is administered orally, in a dose equivalent to 0 1 gram ($1\frac{1}{2}$ grains) per kilogram of body weight in combination with equal amounts of sodium bicarbonate, or subcutaneously or intramuscularly in the form of prontosil in doses of 3 cc per kilogram of body weight in 24 hours

As has been said before, some degree of *dehydration* accompanies all severe burns, as a result of the loss of fluid into and from the burned area and the shift of water distribution following the shock The replacement of this fluid loss is one of the most important phases of the general treatment and should be begun as soon as possible after the patient's admission to the hospital In the case of primary shock such replacement maintains the blood pressure, and in secondary shock it neutralizes the toxins, relieves the concentration of the blood, and aids kidney function The details of water balance are discussed in Chapter V. Briefly, the choice and amount of fluid are calculated by the extent and severity of the burn in relation to the size and age of the patient, by the intake and output of fluids, by blood pressure readings, and by laboratory tests, such as urine examination, hemoglobin determination, erythrocyte count, and blood chlorid estimation It is advisable to have the patient blood-typed immediately after admission in case transfusion becomes necessary.

The ideal fluid for the purpose is blood plasma because of the low percentage of plasma proteins and the high blood concentration associated with burns. Whole blood is contraindicated except in cases of hemorrhage or anemia, as it would tend to a further increase of the already high concentration. In order to raise the low chlorid content, normal salt solution is also given, although owing to the permeability of the capillary walls, there is danger that the fluid may escape, carrying blood constituents in its train and leaving the blood more concentrated in cellular elements and lower in plasma than before.

If there is much vomiting, some degree of acidosis will be present. This is combated by means of a 5 per cent glucose solution and 15-grain doses of sodium bicarbonate every 5 or 6 hours until the urine becomes alkaline (p 372) Ordinarily, fluids can be safely administered in amounts equivalent to 100 cc. per kilogram of body weight

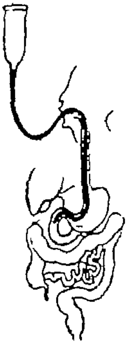


Fig 168. Duodenal tube to supply fluids in case of vomiting.

a day until the capillaries have lost their abnormal permeability As soon as the circulation becomes re-established, the excess fluid is readily excreted.

In the absence of vomiting, fluids are preferably given by mouth in the form of sweetened drinks and fruit juices but if vomiting is present, a duodenal tube may be used to advantage and kept in place as long as necessary (fig 168) If neither method is feasible, the fluid is administered intravenously either as a continuous drip at the rate of 3 cc. per minute for the first 2 or 3 days, or by 2 or 3 daily infusions of 1,000 cc. of 5 per cent glucose in normal salt solution given at the rate of 25 cc. per minute (p 362)

When the critical period has passed, the patient is kept at rest in bed from 5 to 7 days or until the temperature has remained normal for 24 hours. The general nutrition is maintained by means of a well-balanced diet of high vitamin and caloric content. In the case of anemic patients, frequent small blood transfusions of 75 to 100 cc. are administered, as they promote healing and lessen the tendency to infection.

Care of Local Lesion

The management of *superficial burns* covering less than 15 per cent of the body surface is governed by the rules laid down for the general treatment of wounds (p. 271). The aim is to prevent infection and relieve pain, and for this the local application of any of the antiseptic ointments or jellies suffices Or the part may be covered with a gauze compress soaked in a 10 per cent solution of sodium bicarbonate or a 1 per cent solution of aluminum acetate These agents relieve the pain and are mildly antiseptic Following the subsidence of the dermatitis a boric ointment or a bland dusting powder is applied to hasten desquamation Paraffin dressings, to be described later (p. 322), may also be used to advantage

In *severe burns* the aim of the local treatment is (1) to protect the burned area against bacterial infection, (2) to prevent loss of fluid and toxic absorption, and (3) to limit cicatricial contraction and thus prevent deformity and impairment of function of the part These aims are best attained if local treatment is instituted immediately after the constitutional symptoms have been attended to, since procrastination may convert a contaminated burn that can be cleaned and made to heal aseptically into an infected one with delayed healing, scarring, and impairment of function

PROTECTION OF WOUND AGAINST BACTERIAL INVASION

This is the crux of the local management In superficial burns if infection can be prevented, the undestroyed islands of epithelium which remain will proliferate and cover the raw surface, thus diminishing the subsequent contraction and eliminating the need for skin grafting, and in deep burns the absence of infection permits of the rapid formation of healthy granulations, and an early application of skin grafts, thus lessening the extent of the ultimate deformity

As in all accidental wounds the first step is a thorough cleansing, to convert the contaminated surface into a clean one; otherwise, the burned area will furnish an ideal field for the development of bacteria, providing them with warmth, moisture, and a pabulum consisting of devitalized tissue Moreover, the coagulating agents to be applied later cannot be depended upon to inhibit this bacterial growth, and the omission of this precautionary cleansing may lead to suppuration beneath the eschar

Before the wound can be properly cleansed, means must first be employed to rel. the pain occasioned by the process If the burn is not extensive and the patie composed, the preliminary hypodermic of morphin may suffice, but in case the p is a child, or if the damage is considerable, anesthesia will be necessary A g anesthetic is best, nitrous oxid and oxygen, vinethene, or cyclopropane being pref to ether, since pulmonary, renal, and hepatic complications are likely to be pre Whatever agent is used, anesthetization should be carried to the third stage, lesser degree of insensibility may lead to shock. If for some reason a general anesth is contraindicated, procain, either in the form of a nerve block or as a circular bl outside of the burned margins, will serve the purpose Butyn or nupercain may a be applied as a surface anesthetic If a local anesthetic is to be injected, the s around the wound must first be cleansed to prevent the introduction of infection

Technic of Cleansing and Débridement As soon as anesthesia has been secured,

the patient is placed on sterile sheets, the original dressing is removed, a fresh sterile one laid over the burn, and the adjacent skin aseptically prepared (p 270) to prevent subsequent contamination of the burned area from its surroundings. Any grease that may be present is dissolved out with benzene or ether The part is shaved with a sharp razor, care being taken to avoid abrading the skin. The area is then scrubbed gently with green soap and water for several minutes the lather being rinsed off with sterile water at frequent intervals, after which the skin is dried with a piece of sterile gauze, swabbed with ether, and washed for a minute or two with a 70 per cent alcohol solution.

When the surrounding skin has been aseptically prepared, the sterile dressing over the burn is removed and the burn itself cleansed and débrided, the process being carried out as expeditiously as possible and with the least amount of trauma and exposure, in order to avoid unnecessary chilling of the body surface and shock. If the burn is extensive, it is a good plan to cleanse it progressively, uncovering only limited areas at a time. Any grease that may have been previously applied as a home remedy must be dissolved out with benzene, alcohol, or ether, as it favors toxic absorption and interferes with the efficacy of the coagulating agent to be used later Superficial contamination is combated by washing the part for 5 to 7 minutes with cotton swabs dipped in green soap and sterile water, the lather being frequently removed with sterile water or Dakin's solution, preferably from an irrigating outfit. Koch (44) prefers white soap in the belief that its action is gentler than that of green soap This cleansing automatically clears the burn of loose skin, charred particles, and other foreign bodies. Following this procedure, the burn is swabbed with 70 per cent alcohol. Stronger antiseptics are best eschewed. Débridement is then carried out lightly and rapidly Vesicles are opened aseptically with sterile forceps and sharp scissors, all loose skin is trimmed away and charred tissue removed to permit of a deeper penetration of the coagulating agent to be applied later During the débridement gloves and instruments are changed frequently as a precaution against infection, and for the same reason the wound is repeatedly flushed with a hot saline solution.

Complete surgical excision of the burned area followed by immediate resurfacing by means of a graft or flap has been advocated (89, 46, 68, 92, 5, 101, 53, 91, 73, 62, 4, 93 54) While such a procedure theoretically protects the patient from infection and absorption of the products of protein decomposition and shortens his convalescence, it is rarely practicable except in the case of small deep burns. Excision, to be of value, must be done while the wound is still in the contaminated stage and before infection has set in (p 271), and during this period it is difficult if not impossible to differentiate the devitalized from the still viable tissue and in consequence either too much or too little may be removed. In the former instance islands of epithelium hair follicles, and skin glands that might otherwise have been saved would be sacrificed and in the latter the purpose would be defeated by the subsequent infection. Furthermore, the precarious condition of the patient is frequently sufficient in itself to contraindicate the procedure.

LIMITATION OF FLUID LOSS FROM BURNED AREA AND PREVENTION OF TOXIC ABSORPTION

To effect this purpose various agents have been advocated. For convenience they will be grouped as follows (A) Those whose effects are dependent upon the tanning principle and (B) those whose action is not dependent upon chemical precipitation.

A Agents Whose Action is Dependent upon Tanning Principle

(1) Tannic Acid Treatment

The employment of tannic acid in the treatment of burns is recorded in Chinese literature as far back as 5000 B C Its first use in modern times, however, must be credited to Davidson (26) who, working on the assumption that the cause of the constitutional phenomena and death from burns was the absorption of a toxic substance formed at the site of the burn, concluded that some protein precipitant applied locally would prevent or minimize this absorption After considerable experimentation he found tannic acid effective for the purpose, and this method of treating burns has since proved to be one of the most important advances in modern therapeutics It not only served to arouse a new enthusiasm in this field, but it has standardized the treatment of burns throughout the world Since its introduction the mortality following burns has dropped from approximately 32 per cent to 12 per cent, and the period of hospitalization has decreased 25 per cent (57) Harkins (38) gives the following table to show the reduction in mortality in several clinics since the introduction of this agent

Author	Other Methods		Tannic Acid	
	Number of Patients	Mortality	Number of Patients	Mortality
		per cent		*per cent*
Bancroft and Rogers (N Y)	90	40 0	114	20 0
Beekman (N Y)	320	37 8	114	14 9
Wilson (Edinburgh)	300	38 7	117	11 1
Mason (Philadelphia)	91	28 5	87	13 3
Harris (Toronto)		26 6		12 0
Langer (Vienna)	86	16 3	65	7 7
Mitchiner (London)	243	9 4	249	2 4
McClure and Allen (Detroit)	118	9 3	358	7 7
Glover (Cleveland)	121	14	556	10 2
Hempel-Jorgenson		40		11 0

The improved prognosis, however, cannot be attributed solely to the effects of the local application of tannic acid Of equal importance in the reduction of mortality, as has been said before, is probably the greater emphasis now being placed upon supportive measures designed to relieve the associated constitutional phenomena and the institution of measures to prevent infection

Advantages and Disadvantages The claims made for tannic acid are as follows (1) It coagulates the devitalized tissues and seals the lymphatics, thereby lessening toxic absorption (2) By its astringent action it decreases fluid loss This advantage, however, has lost considerable weight since McClure's (56) demonstration that evaporation from the burned surface has but a slight effect on the production of dehydration after a burn (3) It forms a tough coating which protects the exposed nerve terminals from mechanical and chemical irritation, and thus relieves pain and reduces the need of sedatives This is perhaps its most impressive feature (4) The tanning converts a soggy draining wound into a dry one, thus rendering conditions unfavorable for bacterial growth (5) Finally, the subsequent open air treatment diminishes trauma,

promotes the comfort of the patient, simplifies the after-care, shortens the period of hospitalization, and reduces the cost of dressings

The greatest drawbacks to the use of tannic acid are the following (1) In the case of superficial burns it may destroy the remaining islands of epithelium, hair follicles, and sebaceous glands which might otherwise have survived to stimulate repair, hence it creates a need for more extensive skin grafting (76) (2) The coagulum is opaque, and so early infection underneath is often overlooked. (3) In deep burns the coagulum has a tendency to adhere, in which case it may require surgical removal. (4) As the coagulum is inflexible, it has a tendency to crack on movement and thus expose the area to infection. When applied around joints it tends to limit their motion and predisposes to ankylosis, its similar action on the chest may induce pneumonia. (5) It retards exfoliation of the devitalized tissue and thus delays the opportunity for surgical resurfacing (6) The tannic acid in the solution rapidly deteriorates to form gallic acid which renders it inert. (7) Finally, in dilute solutions it is not a germicide.

In order to increase its stability and at the same time reduce the tendency to infection beneath the eschar, the addition of various chemicals has been suggested, the most efficacious of which have been found to be acriflavin in a dilution of 1 1,000 (94 36, 18) and hexylresorcinol in a dilution of 1 2,000 The Medical Research Council (97) suggest that the tannic acid powder be dissolved in a 1 2,000 solution of corrosive sublimate. The use of such an agent, however, would seem to be fraught with danger, especially in the case of extensive burns, since the absorption of mercury from a large raw surface is apt to lead to intoxication. Bettman (12) supplements the tannic acid treatment by spraying the part with a 10 per cent solution of silver nitrate and states that the eschar is formed in $\frac{1}{4}$ the amount of time required when tannic acid is used alone. "The burned tissues become black almost immediately All oozing and leaky areas are sealed at once and the patient is encased in an impervious antiseptic dressing that has formed in seconds instead of hours." In view of the fact that tannic acid solutions are decidedly acid, having a pH value of 2 92 to 3 16, Seeger (74) advises that they be neutralized with *sodium bicarbonate* to make them equal the pH content of the blood, and claims that such solutions effect a more uniform tanning of greater penetration and occasion less edema. Tannic acid solutions must be freshly prepared, because standing will convert tannic acid into gallic acid which is inert. In the absence of tannic acid powder, tea as we drink it may be used as a substitute, as it contains 2 to 5 per cent tannic acid.

Modes of Application. If tannic acid is to be used it must be applied within the first few hours after the infliction of the burn If more than 24 hours have elapsed before treatment, the area will have passed from the contaminated to the infected stage, at which time there would be no point in coagulating the area, since the eschar would merely cover the raw surface and lock up any possible underlying infection Under such circumstances it is best to have recourse to open drainage by means of hot moist saline dressings until the surface is clean enough for grafting

Davidson (26) first used tannic acid as a 2.5 per cent solution and applied it in the form of a warm compress. He also attempted to incorporate the acid in an ointment but without success because the oily base counteracted its tanning effect. Later he applied the agent in the form of a spray using a 5 per cent aqueous solution, and also succeeded in making a 5 per cent gel in a water-soluble base He believed that solutions of greater concentration caused too rapid a surface fixation, inhibiting the effect of the

tannic acid on the deeper layers Moreover, highly concentrated solutions are too astringent and produce undesirable local effects, such as cellular destruction, swelling, and edema

Tannic acid may be employed in the form of (1) *a spray*, (2) *a compress*, (3) *a gel*, and (4) *a tannic acid bath*

Tannic Acid Spray. Tannic acid is most conveniently applied by means of a spray After the area has been cleansed, the patient is placed on sterile linen If the affected area is in the vicinity of a joint, the part is fixed in full extension before applying the spray, as otherwise movement may result in cracking of the coagulum In the case of burns of the hand the fingers should be splinted in a separated position to guard against webbing deformities If the patient is a child, it is well to tie the hands to the side of the bed while the eschar is being formed, in order to prevent infection of the coagulum by the fingers A 5 per cent solution of the agent is sprayed over the

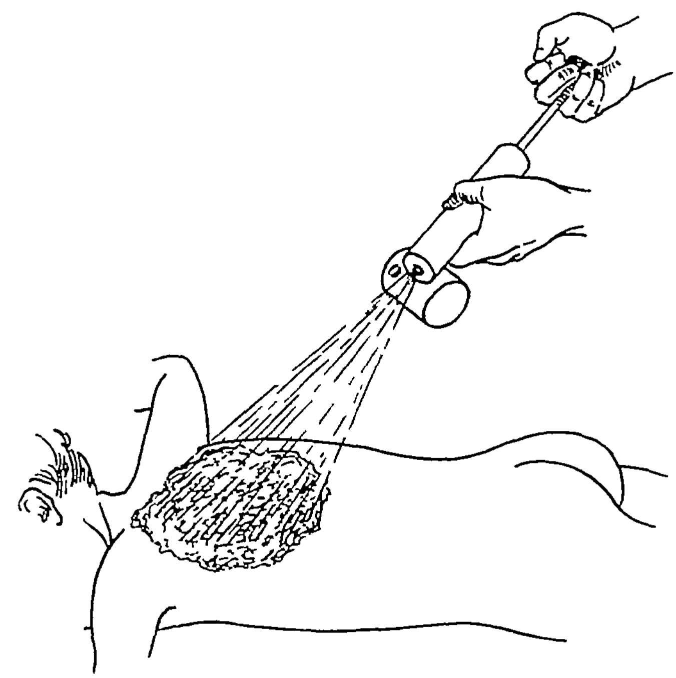


FIG 169 Application of tannic acid spray to burned area by means of ordinary "flit-gun" (Christopher's Surgery)

burned area by means of a sterile atomizer made of glass and hard rubber and equipped with an adaptable nozzle, so that the less accessible parts of the body may be sprayed without the danger of the solution running out of the container For continued use metal sprayers are objectionable, as they become corroded by the acid, but in the case of an emergency an ordinary "flit-gun" will serve the purpose (fig 169) The spraying process is repeated every 15 or 30 minutes for 3 to 4 hours, and thereafter every 3 to 4 hours until a firm, smooth eschar with well-defined edges corresponding to the limits of the destroyed epithelium is formed A thick eschar is to be avoided, as it is liable to crack upon movement and pave the way to infection, and on the fingers it may act as a tourniquet, obstructing their blood supply In the intervals between the applications the sprayed area is placed beneath a wire cage or cradle heated by means of several electric light bulbs suspended from the top This apparatus serves to keep the bedclothes away from the coagulum, and the heat hastens the tanning

process. The temperature within the cradle should be maintained at between 85 and 90°F Greater heat would cause too rapid drying and prevent the solution from penetrating the deeper layers of the affected part. When the extremities of the body are involved, they are suspended in slings within the cradle to permit of a free circulation of air around them As an alternative to the heated cradle, a hot-air blower similar to those used for drying the hair may be substituted.

After the eschar has been formed it should be carefully watched, especially when previous cleansing was delayed or inefficient, or when the spray was applied around joints where cracking is likely, or over contiguous surfaces subject to maceration.

In the case of superficial burns provided infection does not supervene, the coagulum remains dry and begins to peel away as soon as the area beneath becomes epithelized. This process usually takes from 10 to 14 days. In deeper burns, however, because the crust is thicker and more adherent to the underlying tissues, it does not separate for 2 or 3 weeks or longer, and owing to the lack of epithelial proliferation beneath it, a large granulating surface remains after its exfoliation. If spontaneous separation does

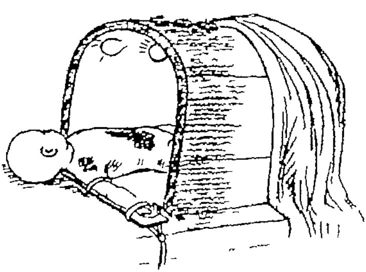


FIG 170 Tanning process hastened by placing patient in electrically heated tent in intervals between applications Sheet to be drawn over cradle, as indicated by arrows.

not take place, the coagulum must be removed surgically under anesthesia. Davidson (24) cautions against the use of moist dressings to soften it, as this may lead to a release of toxins and absorption. Wilson (97) believes that oily dressings are objectionable on similar grounds.

Should the coagulum become elevated by secretions or should it crack or break away, it is aseptically removed, the exposed surface cleaned and dried, and the tannic acid reapplied, if access of bacteria to the wound is to be prevented In the event of infection, evidenced by a floating of the coagulum, pain, and a rise in temperature, drainage must be instituted immediately to prevent septic absorption. In such cases a sedative is administered, the coagulum is either opened in its dependent part or removed, and the area treated like any infected wound—i.e., by the application of fomentations of boric acid or by continuous irrigation with Dakin's solution (p 276)

Tannic Acid Compress In cases where the burn is so situated that the affected area cannot be conveniently sprayed—as, for example, on the face—tannic acid compresses may be substituted. Four to 6 layers of gauze or linen, cut to extend well

beyond the margins of the burn and saturated with a 2 5 to 5 per cent solution of tannic acid, are laid over the area and secured by means of a light bandage The dressing is removed and reapplied at 4- to 5-hour intervals, until the area is tanned to a mahogany brown, 3 or 4 applications being usually required In the interval between dressings the patient is placed in an electrically heated tent (fig 170), in order to hasten the process of tanning The balance of the treatment is the same as when the spray is used.

Tannic Acid Gel A gel of 5 per cent tannic acid in a water-soluble base is preferable to a spray for burns about the eyes, nose, and mouth, as the spray incurs the danger of injury to the mucous membrane One objection to its use, however, is that it produces slower tanning, and thus predisposes to infection It should be applied as a thick layer over the affected part and covered with a bandage The burn is inspected every 2 or 3 days thereafter and more gel is applied as needed

Tannic Acid Bath Tannic acid may also be applied in the form of a continuous warm bath Wells (90) enthusiastically advocates this method The patient is placed in a tub filled with a warm tannic acid solution, enough of the powder being used to give the bath a muddy color, the temperature is regulated solely by the comfort of the patient Loosened skin is removed by means of thumb-forceps and scissors, and blisters are wiped away with gauze Contiguous skin surfaces are scrupulously scrubbed with soap and water When the tub becomes grossly fouled, it is drained, cleaned, and immediately refilled with a fresh solution The patient is kept in the bath for a full 3 hours, after which he is transferred to a warm room, placed in bed, and kept absolutely dry by means of a continuous draft of warm air from a commercial hair-dryer For about 72 hours thereafter the burned area is sprayed at frequent intervals in the usual manner with a 5 per cent solution of tannic acid (fig 169) The method has obvious disadvantages· it requires special equipment and constant attendance, it is depressing to the heart, and the immersion further impairs the function of the skin

(2) Gentian Violet

Based on the theory that the constitutional reaction following burns is due to bacterial infection rather than the absorption of proteolytic toxins from the burned tissues, efforts have been made to develop an agent possessing greater bacteriostatic and bactericidal properties than tannic acid Aldrich and Firor (1929) found that the predominating organism present was the hemolytic streptococcus and in 1929 advocated the use of gentian violet because of its selective action on this organism Since the dye has little effect on Gram-negative bacteria, Aldrich in 1937 combined brilliant green with acriviolet and stated that its superiority over gentian violet was equal to that of gentian violet over tannic acid, although he does not believe it to be the final answer to all the problems presented by burns

The claims made for the dye are (1) that it possesses most of the beneficial qualities of tannic acid and (2) that it forms a lighter and more flexible eschar, a decided advantage in burns around joints, since it does not restrict movement and thereby enhances the functional results Moreover, the thinness of the eschar facilitates the detection of underlying infection In addition, the antiseptic properties of the dye permit of a less radical débridement and warrant its application even in the presence of infec-

tion. Finally, the crust, unlike that caused by tannic acid, can be soaked off, without the danger of destroying any islands of epithelium remaining beneath. The greatest drawback to its use, however is its lack of astringent property, which results in a loss of tissue fluid.

It is applied in the same manner as tannic acid After the usual cleansing the area is sprayed with a 1 or 2 per cent aqueous solution at 5-minute intervals for the first hour, at 15-minute intervals for the second hour, and ½-hourly for 24 hours thereafter

A gel of a 1 per cent solution of gentian violet in a water soluble base is also available and is particularly applicable to ambulatory cases. A generous coat is applied over the burn and covered with a bandage which is kept in place for 10 days.

(3) Ferric Chlorid

Ferric chlorid is applied as a 5 per cent solution in the same manner as tannic acid. Within 6 to 24 hours it forms a transparent elastic coagulum which is of advantage in the case of burns around joints, as it permits of early movement. But the intense pain occasioned by its application constitutes a serious objection to its use (21, 75)

B Agents Whose Action is Not Dependent upon Chemical Precipitation

(1) Wet Compresses and Baths

On the grounds that the coagulum formed by means of chemical precipitants inhibits the natural process of sloughing in burned areas thus interfering with natural repair and delaying operative intervention, Blair and Brown (13, 14), Crile (23), and others advocate soaking of the part in plain water physiologic solutions of sodium chlorid, mild antiseptics, and hypertonic salt solutions. They state that this treatment will cleanse the burned areas sufficiently to permit of grafting within 3 to 5 weeks.

(2) Ointments

A great variety of ointments have been employed in the past in the treatment of burns. While these agents relieve pain by excluding air from the wound and facilitate change of dressings, they do not prevent fluid loss from the burned area, are not sufficiently bacteriostatic to inhibit infection lead to maceration of the skin, and delay epithelization. Since the introduction of tannic acid, ointments have been largely discarded except in the case of burns of first degree, those located in the vicinity of body orifices which are difficult to keep clean, and those around the fingers and toes where a tannic acid eschar would be likely to crack and lead to infection. Loehr (49) advocates the use of an ointment containing 75 per cent cod liver oil and 25 per cent wax and states that it is germicidal, liquifies necrotic tissue, and by its high vitamin content stimulates the growth of epithelium

(3) Picric Acid

Picric acid was introduced by Thiéry (77) in 1894 and enjoyed great popularity in the treatment of burns until the end of the World War It is employed as a 1 per cent solution. While it possesses considerable analgesic properties and stimulates the

proliferation of epithelium, its tendency to produce dermatitis and intoxication constitutes a serious objection to its use

(4) Paraffin Dressings

Paraffin dressings consisting of an artificial shell of gauze and wax prevent crusting and favor epithelization (41) The burned area is washed with a mild antiseptic, such as boric acid, care being taken not to open the vesicles It is then dried and covered with a thin layer of paraffin mixture applied by means of a spray at a temperature of 55 to 60°C Over this is placed a pad of sterile gauze 6 mm in thickness, covered by another layer of paraffin, the whole being secured by a bandage The dressing is removed in 24 to 48 hours, after which time the part is sprinkled with a dusting powder or smeared with boric ointment

MANAGEMENT OF BURNS INVOLVING SPECIAL AREAS

The treatment of burns on the *face* is of particular significance because of the great disfigurement they occasion and their liability to interfere with the function of the special sense organs Therefore, even slight burns in this region must receive careful attention Facial burns are best treated with Metanic Jelly, a gel consisting of 5 per cent tannic acid in a water-soluble base, metaphen 1 5,000, and benzyl alcohol 4 per cent If tannic acid is used in the form of a spray, the eyelids, nostrils, and mouth are first covered with pads of moist saline gauze in order to protect the mucous membranes against its irritating effect

In burns of the *eye* pain is controlled by the instillation of cocain, and infection prevented by irrigations with a mild antiseptic solution, such as boric acid As a precaution against synechia of the iris, the pupils should be kept dilated, and to prevent the eyelid from adhering to the eyeball, warm sterile vaselin should be instilled and the lids frequently moved A glass shell placed inside the conjunctival sac has been found to accomplish the same purpose

In burns of the exposed *mucous membranes of the nose and mouth* pain is relieved by painting the parts with 1 per cent nupercain, followed by the application of a bland ointment, such as cold cream, vaselin, or lanolin

In the case of burns around the *joints* the main objective is the prevention of ankylosis induced by prolonged immobilization and by the matting together of tendons due to infection The use of tannic acid is to be avoided, as the rigid eschar interferes with the free movement of the joint The best results are obtained by means of open drainage After the usual cleansing and débridement moist compresses of neutral acriflavin 1 5,000 or 10 per cent sodium bicarbonate solution are applied Burns of the *hands* and *feet* respond favorably to continuous immersions in warm normal salt solution As a precaution against subsequent disabling deformities, the joint should be splinted in such a position as to permit of maximum function (fig 171) Fingers are dressed in full abduction, small pads of wool being pressed between them to prevent webbing The use of tannic acid is best avoided, as the contraction of the thick coagulum may impair the blood supply Passive motion is begun on the second or third day, and active motion should follow soon thereafter

The greatest problem presented by burns of the *perineum* is the difficulty of warding

off infection due to discharges and of keeping the eschar dry Ointments are unsatisfactory, in that they predispose to infection. Probably the most satisfactory results are obtained from the use of antiseptic compresses of boric acid or sodium bicarbonate. In order to prevent contraction and web formation, the thighs should be spread apart during the healing process, and to avoid vulval adhesions pledgets of cotton soaked in an antiseptic solution should be inserted in the vagina.

MANAGEMENT OF OLD UNHEALED BURNS

The treatment following the spontaneous exfoliation of the eschar or its surgical removal will depend upon the nature of the underlying surface. Obviously, if epi

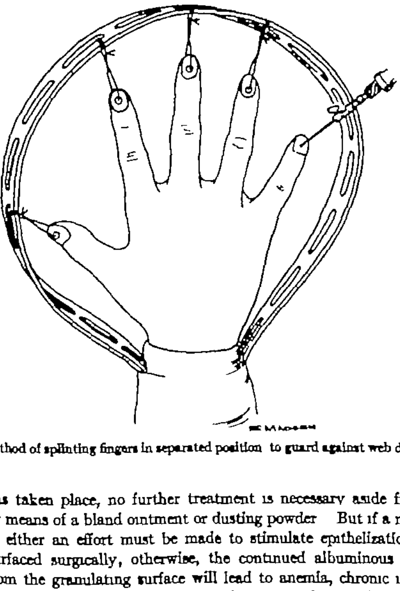


FIG. 171. Method of splinting fingers in separated position to guard against web deformities following burns.

thelization has taken place, no further treatment is necessary aside from protection of the part by means of a bland ointment or dusting powder But if a raw granulating area remains, either an effort must be made to stimulate epithelization, or the area must be resurfaced surgically, otherwise, the continued albuminous drain and the absorption from the granulating surface will lead to anemia, chronic invalidism, and protracted healing complicated by crippling adhesions and gross disfigurement. The management presents the same problems as that concerned with other types of granulating surfaces and is discussed in detail in Chapter II.

Briefly if *islands of germinal epithelium exist*, healing will eventually take place without the need for skin grafting All that is required is that the granulations be kept flat and aseptic and that epithelization be stimulated. If the granulations, by

their red clean color, show evidence of being healthy, an aseptic pressure dressing (p 124) is applied as a protection against mechanical irritation and infection To prevent adhesion of the dressing a layer of perforated cellophane or some other non-adherent material is interposed between it and the granulating surface A good substitute for the pressure dressing is one composed of paraffin, as described on page 128 If the granulations are found to be sluggish, gray, and infected, moist dressings saturated with some mild antiseptic, such as boric acid, hypertonic saline, hexylresorcinol, Dakin's solution, or merthiolate are used Epithelization is stimulated by the application of ointments, such as scarlet red, zinc oxid, boric acid, and ammoniated mercury, or by means of ultraviolet rays Recently fish-liver oil has been enthusiastically advocated (67), the claims made for the agent being that it reduces infection, promotes healthy granulations, and stimulates epithelization to a degree not observed in other forms of treatment While there is no general agreement as to the factor responsible for these favorable results, they are generally attributed to its high vitamin content.

Surgical Resurfacing

In cases where the tissue destruction is so considerable that no germinal epithelium remains, spontaneous epithelization is not to be expected The wound, if left to itself, can be closed only by a slow tedious epithelization from the margins resulting in a thick, unstable scar, or by a drawing in of the adjacent tissues with great deformity Under such circumstances early surgical resurfacing is the best solution to the problem In all but the mildest grades of burns "traction or fixation, even when carefully applied, fail in its object and may be detrimental" (14) In this connection Koch (44) observes that if the process is permitted to take place without interference, healing proceeds rapidly, whereas if flexion is prevented, the wound cannot diminish in size, healing is delayed, and infection and further scar formation ensues

Before resurfacing can be satisfactorily carried out, however, the patient's body chemistry must be brought to an optimum by rest, sunlight, maintenance of fluid balance, adequate elimination, and an easily assimilable nutritious diet Repeated blood transfusions for the relief of anemia are of great value Systemic conditions, such as diabetes, nephritis, and cardiac lesions, must be appropriately managed Chemotherapy on the whole is of little benefit, but in sulfanilamid a chemical agent has been evolved which has given encouraging results in cases of streptococcic infection and may be employed when indicated The dosage and method of administration are discussed on page 312

Preparation of Bed. If the graft is to be successful, the granulating surface must be reasonably free from infection at the time of its application. The steps by which this may be accomplished are given in detail in Chapter III Briefly, the granulations are prepared by the application of heat and moisture in the form of warm moist dressings, by elevation of the affected part, and rest It is essential that the dressings be kept continually wet, for if allowed to dry out they soon become hard, prevent the escape of discharges, and impede the circulation After the surrounding skin has been shaved and cleansed, the granulations are covered with a layer of cellophane perforated to permit of the escape of secretions, and this is overlaid with a sterile dressing wrung out of hot normal salt or boric acid solution On this is superimposed a piece of

rubber tissue, and the whole enclosed in a bandage. In order that the dressing may be rendered effective, heat must be maintained at a constant temperature, and this is best accomplished if the part is placed in an electrically heated cradle as described on page 318 Should the part show evidence of maceration, the wet dressing is removed and the application of dry heat continued until the wound discharges cease and the granulations become pink and firm, at which time they are ready for grafting Inspection of the granulations furnishes a better index to the character of the bed than bacterial counts.

Various *antiseptics* have been advocated to hasten the preparation of the granulations for the reception of the graft, but their importance has probably been exaggerated. Of the *halogen derivatives* Dakin's solution and azochloramid are the most popular The details of their preparation and application are given on page 46

The use of *coal tar derivatives* on granulating surfaces has been generally discarded because of their local caustic action and their irritating effect on the kidney after absorption. Of the *dyes* gentian violet 1 per cent, and flavin in a dilution of 1 1 000 are the ones most commonly employed. Although they are non-irritating to the tissues, they inhibit the formation of granulations. *Oxidizing agents*, such as hydrogen peroxid potassium permanganate, and zinc peroxid, are used for the cleansing of granulating surfaces. These agents are inactivated by albuminous secretions and are said to exert their antiseptic properties by the liberation of oxygen. *Alcohol* in a 70 per cent solution not only clears up the granulations but tends to shrink them. *Boric acid* and *normal salt* solution are probably as effective as any of the foregoing antiseptics and are less irritating to the tissues.

Another suggestion for the preparation of the granulating surface for grafting is the use of ultraviolet rays.

If the granulations are exuberant and boggy, they are shaved off with a sharp knife down to a clean, even, fibrous tissue base. The use of caustics for this purpose is to be avoided as they destroy the growing edges of the skin and thus delay healing

Choice of Graft. The nature of the graft to be employed will depend upon the state of the granulations, the general condition of the patient, and the location and size of the denuded area. If the granulations are reasonably healthy, thick razor grafts are the most suitable from the standpoint of both appearance and stability (17) The details of their application are discussed in Chapter II. Full thickness grafts and flaps are ordinarily unsuitable for use on granulating surfaces. They are valuable, however in late plastic repair (p 326) When the general condition of the patient does not permit of the more extensive operation necessitated by the application of a thicker graft, a large thin razor graft may be applied instead, since it occasions less shock and will remain viable on a less aseptic base. Although these grafts are ordinarily unsuitable for burns, as they contain only very little of the dermis and thus predispose to contraction nevertheless they will serve as a temporary covering, facilitate healing and frequently pave the way for the use of a permanent thicker graft when the patient's general condition allows. Homografts may also be employed for the same purpose.

If the granulations are infected or the raw surface is so extensive that a sufficiently large donor area is unavailable, the part may be covered with small deep grafts. While these grafts are accompanied by considerable scarring and their cosmetic effects are inferior to those produced by other grafts, still they are of great value under the

circumstances, since they are the type most likely to "take," require a less specialized technic than razor grafts, are most economical in the amount of donor skin required, and afford but little discomfort to the patient, as they can be applied under local anesthesia

MANAGEMENT OF CONTRACTURES AND DEFORMITIES FOLLOWING BURNS

Slight contractures and deformities consequent upon burns can frequently be corrected by means of systematic massage, graduated exercises, and the application

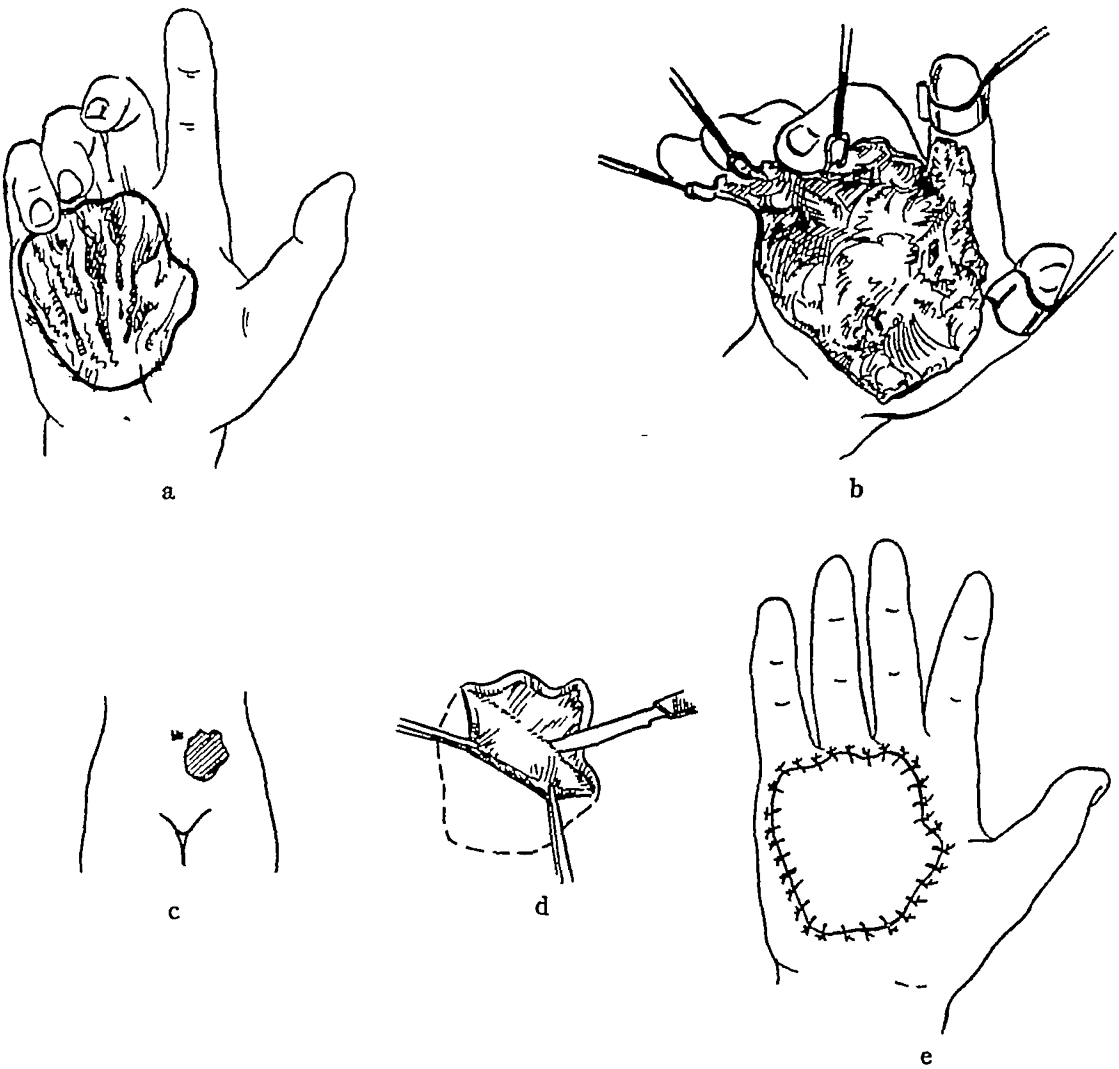


FIG 172 Plastic repair of palm by full thickness skin graft, following cicatricial burn contraction *a*, burn scar outlined by incision *b*, scar tissue excised *c*, graft outlined on abdomen according to pattern *d*, graft removed *e*, graft sutured over defect. (Koch and Kanavel)

of heat (p 1369) If after 6 months of such treatment deformity and interference with function persist, plastic repair must be resorted to It is impossible to outline a routine procedure at this point, since the measures adopted will depend entirely upon the extent of tissue loss, the degree of deformity, the nature of the scar, and the condition of the surrounding skin in each individual case The various methods whereby cor-

rection may be accomplished are considered in detail in the section dealing with scars. Briefly, the consecutive steps are the removal of the scar tissue, the re-establishment of the normal relationships between the parts, and the covering of the remaining defect with healthy tissue. As a rule it is advisable to excise the scar tissue throughout its entire extent, but when tendons are involved, it is well to leave a thin layer of scar tissue attached rather than risk further adhesions by their exposure. After excision of the cicatrix the tissues are "untangled" and placed in their proper relationships. In the vicinity of joints the deformity is overcome by gradual stretching, since sudden force may tear blood vessels, nerves, and tendons which have become shortened as a result of the contracture. When the deformity has been overcome, an accurate pattern of the surface defect is made, and a full thickness graft or flap is cut and sutured into the defect (figs. 172–178)

In the eyelids the tissues are sufficiently lax to permit of the excision of the scar and the closure of the secondary defect by direct approximation. If the orbicularis oculi muscle has been destroyed, it may be replaced with a flap brought down from

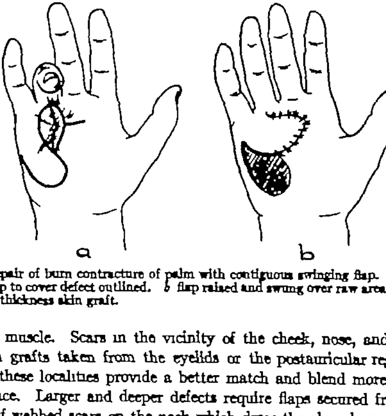


FIG 173 Repair of burn contracture of palm with contiguous swinging flap. *a*, scar tissue to be removed and flap to cover defect outlined. *b* flap raised and swung over raw area. Secondary defect covered by full thickness skin graft.

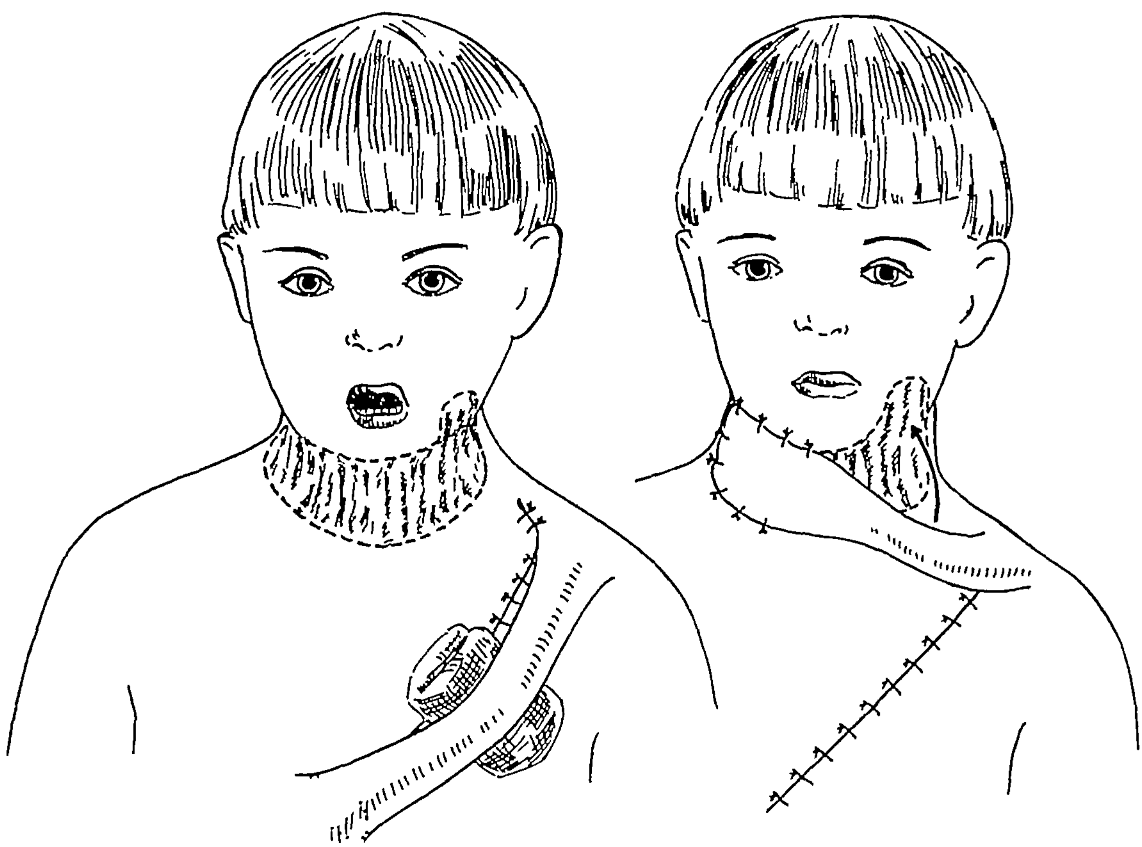
the temporal muscle. Scars in the vicinity of the cheek, nose, and mouth are best repaired with grafts taken from the eyelids or the postauricular region (fig 467), as tissues from these localities provide a better match and blend more evenly with the rest of the face. Larger and deeper defects require flaps secured from distant sites. In the case of webbed scars on the neck which draw the chin downward or sideways and in those of the axilla which bind the arm to the chest wall, the Z-plastic operation gives good results, provided the adjacent skin is normal (fig 176) Denser scars in these regions must be removed and replaced with full thickness grafts or flaps (figs. 174–175, 177–178)

SPECIAL BURNS

Irradiation Burns

Some degree of burning of the skin is inevitably associated with all forms of irradiation therapy, inasmuch as the rays, in order to produce the intended effect on

the deeper tissues, must necessarily inflict a certain amount of damage upon the skin through which they pass Fortunately severe skin reactions resulting from this treatment are not encountered as frequently as in the past, owing to a better understanding of the effects of irradiation, the use of fractional doses, and the emphasis on protective measures for the safeguarding of the surrounding area The extent of skin damage following irradiation ranges from a simple erythema to a complete destruction of the whole thickness of the skin and underlying structures, depending upon the size of the dose and the radiosensitivity of the tissues In this connection, MacKee (52) states "Embryonic tissue, young cells, cells at or near the stage of division, physiologically active cells and lymphoid tissue are radiosensitive, but all other normal



a b

FIG 174 Tubed flap from chest used to repair burn scar of neck *a*, flap tubed on chest. *b*, distal end of flap severed, opened up, and sutured into prepared area in neck After vascularization, balance of scar removed, and raw area covered with remaining pedicle of flap

tissue is relatively radioresistant" Microscopically, the early changes are those of inflammation, with proliferation and exfoliation of the epithelial cells Later the dermis, including the elastic tissue, hair follicles, and glandular elements, undergoes degeneration, followed by atrophy and sclerosis The capillaries show a progressive proliferative endarteritis, characterized by a diminution in their caliber or by a complete obliteration of their lumina As a result the tissues which they nourish become ischemic and may undergo necrosis and ulceration

Irradiation burns may result from a single large dose or repeated small doses of x-ray or radium They may appear either shortly after treatment or not for months or even years later They are accompanied by symptoms ranging from slight dis-

comfort, tingling, and itching, to excruciating pain, they run a chronic course, and resist all forms of treatment.

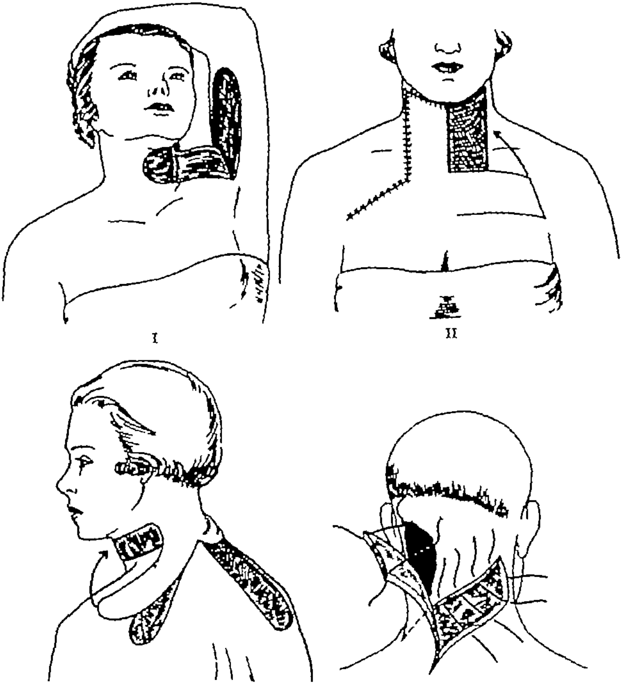


FIG. 175 Repair of extensive burn scars on neck by direct transfer of flaps *I* arm flap pedicled at shoulder raised, and free end rotated into posterior part of defect. (Under surface of flap can be protected by covering it with reflected scar tissue) After vascularization pedicle cut and swung into balance of defect. Secondary wound skin-grafted (Koch and Kanavel) *II* method of utilizing horizontal chest flaps for repair of neck defect (Lexer) *III* utilization of dorsal flaps for same purpose. Secondary wound skin grafted (Berger) *IV* utilization of dorsal flap for repair of postauricular defect following removal of scar tissue (Lexer)

The *early effects* of irradiation burns are analogous to those arising from burns due to other causes. The initial reaction manifests itself in the form of a faint erythema varying in color from a pink to a bluish red, appearing 4 to 10 days after irradiation

and, in the case of superficial burns, gradually subsiding within 1 to 3 weeks. In moderately severe cases the erythema is more marked and is accompanied by vesicles and edema, in time the epidermis exfoliates in patches and leaves a moist, bright, pink surface In serious burns the entire thickness of the skin, subcutaneous tissue, fascia, and muscles may undergo necrosis, followed by slow healing and the formation of a wrinkled cicatrix Associated phenomena include temporary or permanent pigmentation or depigmentation, transient or permanent alopecia, telangiectasis, pruritus, keratosis, recurrent ulcerations, and malignant degeneration

The *late effects* manifest themselves months or even years after irradiation treatment and take the form of late necrosis, dermatitis, or malignant degeneration The necrosis may appear without apparent cause or may follow some slight trauma It begins as a small deep ulcer located in the center of the irradiated area Its margins are sharply defined, and its base is covered with a dry, hard slough The patient complains of

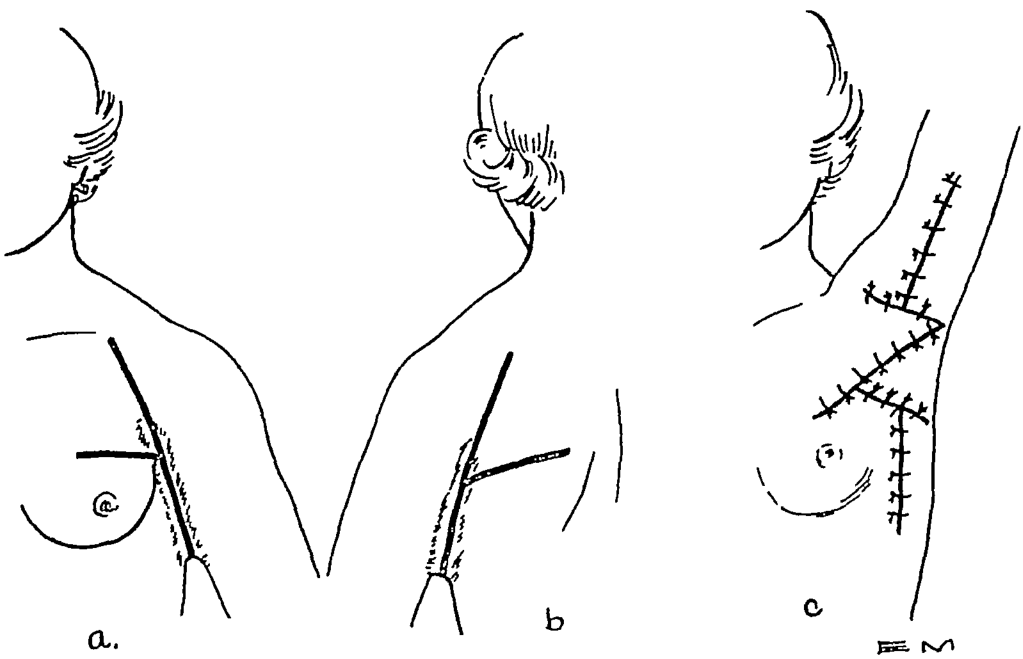


Fig 176 Repair of burn scar in axilla by utilization of anterior and posterior flaps *a*, flap outlined on anterior surface of axilla *b*, flap outlined on posterior surface *c*, arm released, and flaps transposed (Piéchaud)

considerable pain Despite treatment healing is slow and may be incomplete even after years Dermatitis ("x-ray or radium skin") usually develops within a year or two following irradiation therapy and is evidenced by telangiectasis, irregular pigmentation, dryness and cracking of the skin accompanied by severe pain, atrophy, and recurrent ulcerations The most tragic sequela of irradiation burns is carcinomatous degeneration, which is usually of the squamous cell variety For details the reader is referred to page 1333

Treatment In the use of irradiation therapy every precaution should be taken to avoid damage to the skin, since once the harm has been done, treatment is difficult These burns can be largely prevented by an accurate individualization of dosage, avoidance of overlapping of the fields, and care in the management of tissues of lowered resistance, such as scar tissue After irradiation the part should be protected for several months against mechanical, chemical, and thermic irritation

Superficial burns of this type are treated in the same manner as superficial burns due to other causes—namely, by the application of bland ointments. Antiseptics and heat are to be avoided because of the low resistance of the tissues. After healing, the part should be shielded from exposure to heat or sun radiation In deep burns, early and wide excision well beyond the limits of endarteritis, telangiectasis, and active keratosis offers the best prospects for the elimination of pain and the prevention of subsequent malignant degeneration The remaining defect is corrected by a plastic operation.

The treatment of irradiation dermatitis is unsatisfactory If the condition is associated with severe pain, ulceration, and contraction, complete excision is required, and this necessarily entails much sacrifice of tissue The resurfacing of the defect is often a problem, inasmuch as the affected area is rendered unsuitable for the re-

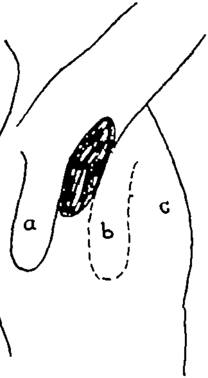


FIG. 177 Repair of burn scar in axilla by flaps from thorax. a, scapular flap (Berger) b, chest flap (Chaput) c chest flap (Jobert)

ception of a graft by the obliteration of its blood vessels. Therefore a flap offers the best prospects for success, since it not only carries its own blood supply, but also furnishes nutrition to the devitalized tissue.

FREEZING

The parts most subject to freezing are the nose, ears, cheeks, hands, and feet. The amount of tissue damage will depend upon the degree of cold, the period of exposure, and the resistance of the tissues. Damp cold, due to its slow evaporation, causes more serious damage than dry cold. Short exposure to intense cold or prolonged exposure to moderate cold is apt to result in chilblains, while prolonged freezing results in gangrene. Extremes of age, debility, and intoxication are predisposing factors.

In the first stage of freezing the part turns pale, due to vasoconstriction and the

slowing of the circulation The patient complains of burning, prickling, and itching sensations followed by numbness If exposure ceases at this point, the part becomes red and edematous from the exudation of a plasmalike fluid into the tissues Large vesicles containing a clear watery fluid form, which either disappear or become in-

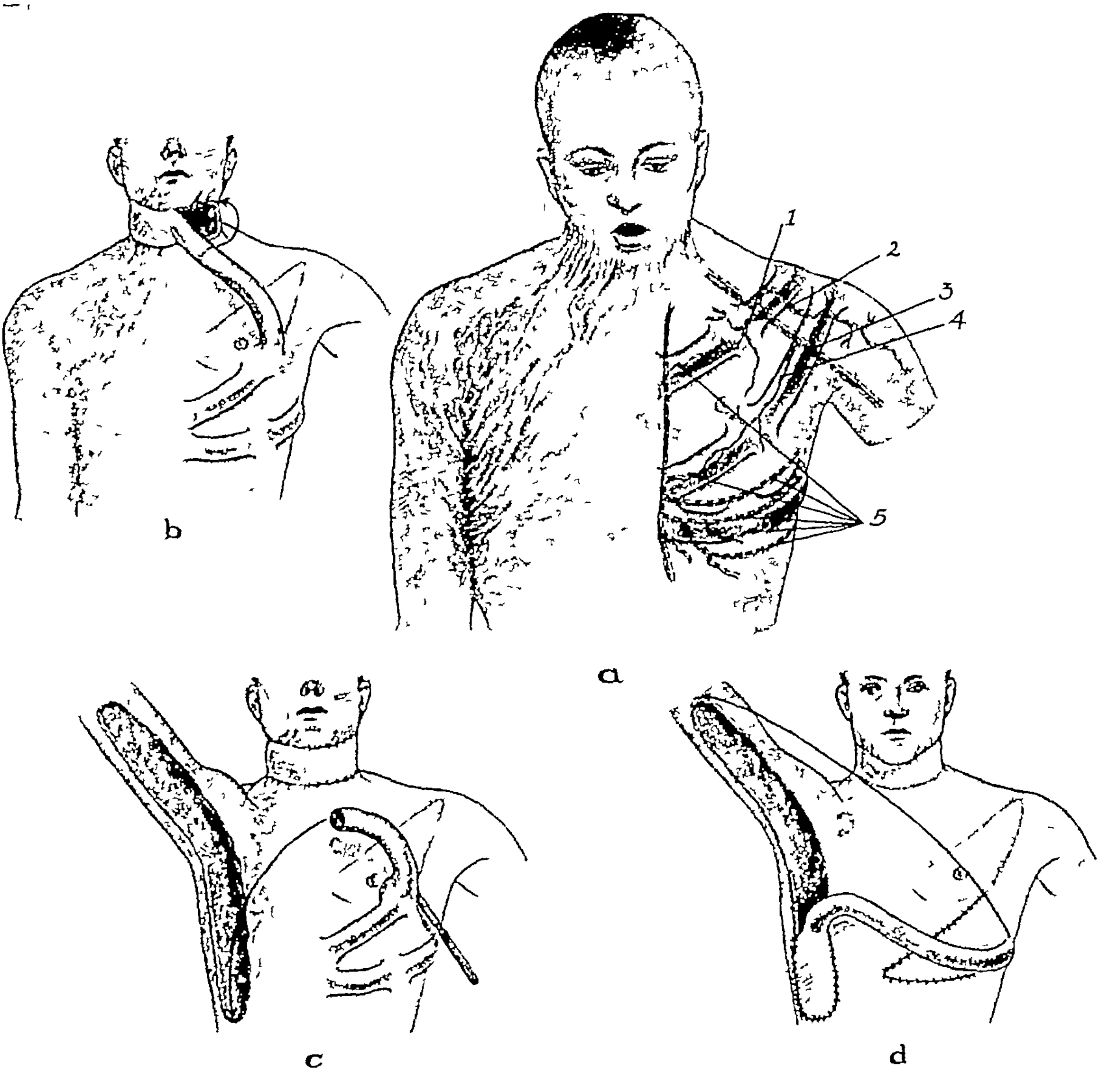


FIG. 178 Repair of extensive scar binding chin and arm to chest with single multipedicled flap *a*, flap tubed and pedicled on *1* pectoral branch of acromiothoracic, *2* deltoid branch, *3* acromiothoracic, *4* long thoracic, and *5* anterior intercostal arteries *b*, upper pedicles severed in stages, to enhance vascularity of flap Scar tissue excised, end of flap opened, and sutured into raw area After vascularization, balance of scar tissue on neck removed, flap cut at site of dotted lines, and sutured into remaining raw area *c–d*, remainder of flap used to reconstruct axilla One set of lateral pedicles cut End of flap opened up and sutured into bed made at lower part of axilla At subsequent stages, balance of pedicles severed progressively, and flap gradually made to replace axillary scar

fected, leaving slowly healing ulcers This condition is referred to as chilblains If exposure is continued, the blood vessels contract still further and eventually there results a local cessation of the circulation, thrombosis of the smaller blood vessels, and gangrene

Treatment The body heat should be restored gradually Too sudden a thawing

may cause vasodilatation, thrombosis, and stasis of the circulation, and the tissues, enfeebled by the already diminished blood supply, may succumb The best plan is to place the patient in a cool room, the temperature of which is gradually raised, and to hold the ungloved hands over the affected area. When thawing is complete, the part is gently cleansed with soap and water, and a dry sterile dressing is applied Moist dressings are contraindicated, as they may open up possible avenues for infection by macerating the skin. The part is splinted in the best functional position, elevated to facilitate lymphatic and venous drainage, and protected against trauma. Active and passive motion should be started early, and massage and baking instituted at a later period.

If gangrene supervenes, it is combated in the same manner as gangrene due to other causes. The part is kept dry and aseptic until a line of demarcation has formed, a process usually requiring from 2 to 6 weeks. It is advisable to allow the slough to separate spontaneously since the tissue loss is frequently less than appearances would indicate. If infection sets in, wet antiseptic dressings are applied. All sloughs are aseptically removed. When infection has been brought under control, any raw areas remaining are resurfaced by means of skin grafts or flaps.

Chemical Burns

The chief differences between chemical burns and those resulting from other causes are that the destructive process occasioned by the former continues until the effect of the cauterizing agent is neutralized, and that the absorption of the agent gives rise to systemic reactions. The extent of damage varies in accordance with the amount and nature of the chemical and the duration of its action The immediate treatment is directed toward a dilution and neutralization of the agent. Dilution is best accomplished by irrigating the part with large quantities of water Attempts to neutralize the caustic chemically before the agent is thoroughly diluted are not advisable, since the heat generated in the process may in itself be sufficient to cause a burn As soon as the poison has been diluted, it is neutralized the agent to be employed depending upon the cause of the damage. For instance, in the case of acid burns it is best to use weak alkalies, such as solutions of sodium bicarbonate, and in alkali burns dilute acids, such as citric acid The subsequent treatment is the same as that indicated for thermic burns.

Electric Burns

Uzac (88) describes two general types of electric burns, namely those due to an accidentally produced arc and those resulting from the passage of an electric current through the tissues. In the former case the injury is caused directly by the incandescent gases between the conductors, and in the latter the tissues are heated by the passage of a current through them. This is known as the Joule effect. The structures that suffer most from electric burns are those offering the greatest resistance to the current, such as skin and tendons.

Locally, these burns appear as yellowish gray lesions sharply differentiated from the surrounding skin A characteristic feature is the greater involvement of subcutaneous as opposed to surface area. Unlike the usual burn this type shows no

toxemic symptoms The lesion is painless, and there is but a slight inflammatory reaction In time aseptic sloughing takes place, leaving a deep surface of coagulation necrosis, which heals slowly, leaving a soft, smooth, pink scar The local treatment of the burn does not differ from that indicated for burns due to other causes

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CHAPTER V

FLUID, SALT AND ACID BASE BALANCE

FLUID BALANCE

Under normal conditions the water content of the body is maintained at a constant level by a delicate adjustment between the intake and output of fluids Any disturbance in the ratio between the total fluid intake and the total output upsets the "water balance" and leads to serious consequences While the body can tolerate a loss of all of its glycogen and fat and 40 per cent of its protein without marked physiologic disturbance, a loss of 20 per cent of its water content results in death (94) In the normal individual water balance is automatically maintained by the satisfying of thirst. But the sick patient may be incapable of supplying his fluid needs, either because he is too ill to appreciate the sense of thirst or because the stomach has lost its retentive power Under these circumstances the ability of the surgeon to supply water parenterally and at the same time compensate for the frequently associated electrolytic, protein, and caloric deficiency represents one of the most significant advances in modern medicine

In order that the therapy employed in the correction of a water imbalance may be fully understood, a review of some of the physiologic features pertinent to normal water balance is essential

Source of Fluid

Body fluid is derived from two sources—namely, imbibed water and ingested food, the amounts of which under normal conditions are regulated by the demands of thirst and hunger The average daily quantity of fluids drunk varies between 800 and 2,000 cc , while the fluid supplied by the ingested foods is equal to approximately 90 per cent of their total weight, 70 per cent being derived directly from their water content and 20 per cent being furnished by the water of oxidation produced in the course of their metabolization For instance, a molecule of carbohydrate is capable of liberating 6 molecules of water, as shown by the following formula $C_6H_{12}O_6 + 6O_2 = 6H_2O + 6CO_2$ An estimation of imbibed fluids can easily be made, but the computation of the quantity of water liberated by the food offers some difficulty, as it varies in accordance with the composition and caloric value of the particular food In the process of oxidation one gram of protein yields 0 4 cc of water, of fat 1 07 cc , and of carbohydrate 0 6 cc (98) It has been proved that for every 100 calories furnished by the ingested food, 10 to 15 cc of water are liberated Thus, in an average diet of 3,000 calories from 300 to 450 grams of water would be furnished during the process of oxidation. This quantity, together with the fluid contained in the food, would furnish from 1,000 to 1,500 cc of water, and added to the average total fluid intake of 800 to 2,000 cc , would bring the total daily intake to from 1,800 cc to 3,500 cc Even in cases of starvation,

when there is no intake of food or liquid whatsoever, the body, as a result of its own tissue catabolism, is capable of elaborating 500 cc. of fluid.

Dissipation of Fluid

Kidney

Normally the amount of waste products eliminated by the kidney averages between 35 and 40 grams daily A kidney capable of *concentrating the urine to a specific* gravity of 1.030 is able to excrete the waste by utilizing only 15 cc. of water per gram. Thus, under normal conditions, 525 to 600 cc. of water are sufficient for the discharge of the body waste. But if the kidney is impaired, it loses its power of concentration and therefore requires a greater quantity of water for the excretion of an equal quantity of waste. In other words, the more serious the kidney damage, the less its concentrating ability, and the greater the volume of water necessary for the excretion of the waste (63) Assuming that the kidney can concentrate the urine to a specific gravity of only 1 015 as much as 50 cc. of water or more per gram may be required, and under such circumstances 1,750 to 2,000 cc. of water become necessary In this connection Bingham (10) presents an interesting table

	Maximum Concentrating Ability	Minimum Water Required to Excrete 15 Grammes of Waste Products
	c. cm.	c. cm
Normal kidneys	1 032–1 029	473
Diseased kidney	1 028–1 025	593
	1 024–1 020	605
	1,019–1 015	850
	1 014–1 010	1 439

From the above figures it can be seen that if the quantity of water available for urine formation is inadequate, there will be a retention of waste products and an alteration in the acid base balance. To prevent such a contingency Coller and Maddock (21) recommend that sufficient water be administered to maintain a minimum urinary output of 1,500 cc. at a specific gravity of 1.015

Skin and Lung

The loss of a certain quantity of water by way of the skin and lung is essential to the maintenance of a constant body temperature, and in view of the importance of this thermotactic function, the skin and lung have a preferential claim on all the water available for excretion. Newburgh and his associates (83) have shown that approximately 25 per cent of the body heat is dissipated through vaporization, the remaining 75 per cent being lost through radiation and convection from the body surface. Under average environmental conditions an adult will vaporize daily from 1,000 to 2 000 cc. of water and a child approximately 850 cc. without visible traces of perspiration. This insensible loss never leads to dehydration. But when there is an increased necessity for the elimination of heat, such as in fever, as much as 5 000 cc. of water may be vaporized daily, and if such a loss is allowed to continue severe dehydration is inevi

table Since the salt concentration of the perspiration is less than that of the body fluid from which it is derived, temporarily there is a greater depletion of water than of salt But the body soon re-establishes its water-salt equilibrium by excreting the excess salt as an isotonic solution through the kidney Thus, the loss of a liter of perspiration becomes equivalent to the deprivation of the body of a like quantity of isotonic salt solution

Gastro-Intestinal Tract

It has been estimated that from 7,500 to 10,000 cc of fluid in the form of saliva, gastric juice, bile, pancreatic juice, and succus entericus is poured into the intestines daily Most of this fluid, however, after fulfilling its function, is reabsorbed, only enough being excreted to facilitate the evacuation of the stools According to Rowntree (94), less than 150 cc of water are needed for the latter purpose Obviously, should an amount of fluid approximating 7,500 to 10,000 cc be diverted from its normal channels through vomiting, diarrhea, etc , serious dehydration may supervene Furthermore, the various digestive juices, although isotonic with the blood, differ from the latter in chemical composition, and their loss occasions a disturbance in the acid base equilibrium (p 344) For example, gastric juice is richer in chlorin and poorer in base than the blood It follows, then, that in the case of a loss of this fluid, as in vomiting, the relatively greater loss of chlorin will force the retained base to combine with the carbonic acid of the blood and will thereby raise the level of the bicarbonate and bring about alkalosis On the other hand, a loss of pancreatic juice, which contains less chlorin and more base than the blood, will result in acidosis

Water Content of Body

Water represents about 70 per cent of the body weight and is distributed in the following manner (fig 179) (1) in the blood plasma, 5 to 9 per cent, (2) in the cells, 45 to 50 per cent, and (3) in the interstitial or extracellular tissue spaces, 15 to 16 per cent Whereas the intracellular fluid is in a state of chemical combination and is therefore not readily available for the restoration of a depleted blood plasma volume, the interstitial fluid, on the other hand, exists as an isotonic saline solution and as such can be utilized by the plasma to meet various bodily needs Thus it acts as a medium for the exchange of nutrition between cells and blood In addition it serves as a reservoir, which in case of dehydration is called upon to sustain the volume of the blood plasma and in the event of edema to store the excess fluid It is a lack of this fluid which is the basic factor in dehydration

Interchange of Water

The normal fluid distribution in the body is maintained by means of a balance of two forces—on the one hand, the hydrostatic pressure within the capillaries which tends to drive the fluid out of the vessels, and on the other, the osmotic pressure of the proteins in the plasma which strives to retain it At the arterial end the hydrostatic pressure is in excess of the osmotic traction, and liquid passes into the tissue spaces. At the venous end the osmotic traction exceeds the hydrostatic pressure, and liquid passes from the tissues into the capillaries (99) (fig 180) Physiologists estimate that if the osmotic pressure were nil and the hydrostatic pressure in the capillaries amounted to

only 10 mm of mercury the entire blood plasma would ooze through the capillary system (an area of approximately 6,000 square meters) in 10 seconds (99) The interaction between these forces is well illustrated in the process of the formation of urine by the kidney Urine is excreted so long as the hydrostatic pressure of the glomerular capillaries exceeds the osmotic pressure of the proteins in the plasma. When the hydrostatic pressure falls to a level equal to or lower than the colloid osmotic pressure in the plasma, the secretion of urine ceases. Ritchie (92) states "As the colloid osmotic pressure within the capillaries is 32 to 35 mm. of water the hydrostatic

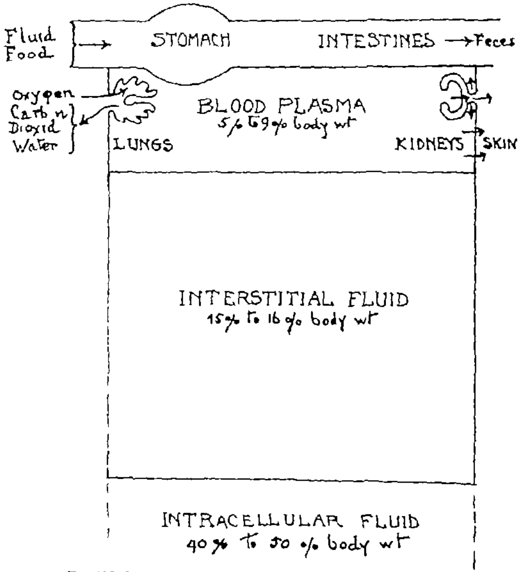

FIG 179 Distribution of water in body (Modified from Gamble)

pressure must be greater than this to drive the fluid out into the interstitial spaces It is at the arterial end of the capillaries that this condition is fulfilled at the venous end on the other hand, there is, as it were, a negative pressure and fluid is accordingly withdrawn into the capillaries from the tissue spaces" (fig 180)

Function of Water

Water is necessary to the performance of every physiologic function It serves as the solvent for the ingested food which can be absorbed through the intestinal wall

only in liquid form The volume of fluid required for this purpose, however, is in excess of that needed permanently in the body, and therefore the superfluous water must be eliminated But since the body is frugal in its activities, it first directs the use of this excess liquid to other physiologic ends Thus the quantity excreted by the kidney is used for the discharge of nitrogenous and other waste material in the form of urine, that lost through the lungs and skin is vaporized as sweat to maintain the body temperature, and that given off by the bowels is utilized for the disposal of the feces Although all the organs have need of fluid for the proper performance of their functions, not all are equally favored, the skin, lungs, alimentary tract, and interstitial tissues enjoying preferential rights over the kidney It is only after their demands have been satisfied that the kidney receives water for the elimination of waste Thus it follows that in the event of excessive vaporization, vomiting, diarrhea, or edema, the prerenal

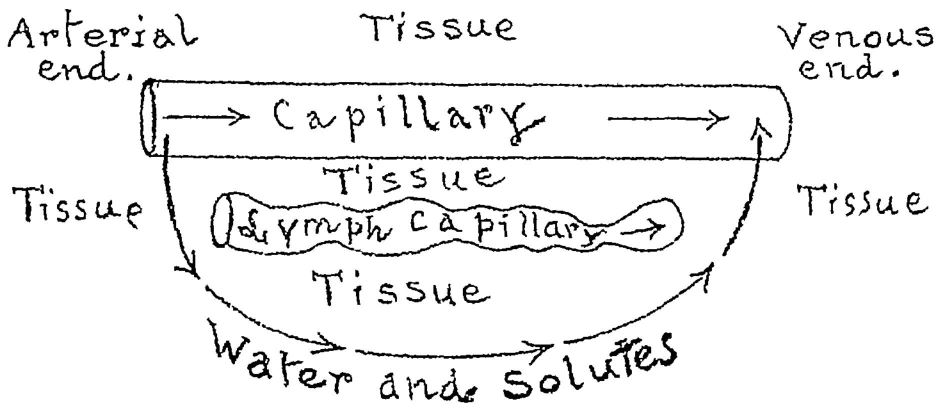

FIG 180 Interchange of water Normal fluid distribution maintained by balance between hydrostatic and osmotic pressure in capillaries For details, see text (Starling)

deviation of fluids may leave so little water that the urinary output will drop to almost nothing

DEHYDRATION

The maintenance of water balance is of vital importance in the case of patients suffering from disorders involving an abnormal loss of body fluids, notably diarrhea, vomiting, excessive perspiration, hemorrhage, gastro-intestinal fistulae, burns, diabetes, and shock In the latter condition the disturbance of water balance is brought about not so much by an actual loss of fluid as by its transference from the vascular bed into the tissue spaces

Evidence of dehydration appears when the loss of water is equivalent to 6 per cent of the patient's body weight (20) The water available for urinary output being insufficient to excrete the normal waste material, the urine becomes scanty and may contain blood and casts In time the kidney itself is damaged in an attempt to relieve itself of its burden under such adverse conditions Because of the fluid depletion the blood plasma volume falls below the normal 50 cc per kilogram of body weight and the blood becomes concentrated, due to a relative increase in the amount of erythrocytes, hemoglobin, and plasma proteins, the non-protein nitrogen rises above 40 mg per cent, and the urea nitrogen above 30 mg per cent The electrolytic pattern of the blood is disturbed, causing acidosis or alkalosis, which in turn incite vomiting accompanied

by further dehydration. Thus a vicious cycle is set up The fluid deficiency interferes with normal vaporization, as a result of which the skin and mucous membranes become hot and dry and the temperature rises. A rough index of the degree of dehydration may be obtained from the *dryness of the skin, tongue, and buccal mucosa and by the intensity of thirst*

Requirements for Water Balance

The quantity of daily fluid required for the maintenance of a normal water balance equals

1 Water for vaporization	2 000 cc.
2. Water for urine	1 500 cc.
3 Water for feces	150 cc.
Total	3 650 cc.

In the case of sick patients, however, the usual requirement of 3,650 cc. is insufficient to maintain this balance because of abnormal losses due to hemorrhage, vomiting, diarrhea, purulent discharges, fluid exudations from large denuded surfaces, and excessive sweating occasioned by fever or by overheating with blankets, hot water bottles, etc. It is estimated that with each degree of elevation in temperature above normal there is an additional daily loss of 500 cc. of water Coller and Maddock (19) have calculated that the average loss of fluid during the first 4 hours of a major operation is 1,000 cc. and that in the early postoperative period there is a further loss of 2,000 cc. daily

In order to determine the fluid requirement of surgical patients, the daily abnormal losses from vomiting, diarrhea, hemorrhage, etc., should be carefully measured and recorded To this total should be added the normal water requirement of 3,650 cc., and from the sum of the above should be subtracted the fluid taken by mouth from time to time The result will equal the quantity of fluid needed to maintain water balance For instance

1 Abnormal fluid loss from vomiting, diarrhea, fistulae, wound exudates etc. (for example)	1 000 cc.
2 Water needed for vaporization	2 000 cc.
3 Water needed for urine	1 500 cc.
4 Water needed for feces	150 cc.
Total	4 650 cc.
Minus water ingested (for example)	100 cc.
Total fluid required for balance	4 550 cc.

Patients who are already in a dehydrated condition when seen require, according to Coller Dick, and Maddock (18) an amount of fluid equal to 6 per cent of body weight. Thus the fluid need will equal

1 Water needed for vaporization	2 000 cc.
2 Water needed for urine	1 500 cc.
3 Water needed for feces	150 cc.
4. Six per cent of body weight (for example, in the case of a person weighing 75 kilograms)	4 500 cc.
Total fluid required	8 150 cc.

Some sort of balance sheet, such as that appended below, should be kept as a check on the patient's intake and output

Name 24 hours ending

Intake		Output	
(1) By mouth	cc	(1) In urine	
(2) By rectum	cc	Sp Gr	
(3) By hypodermoclysis	cc.	Amount	cc
(4) Intravenously	cc	(2) From skin and lungs	cc
		(3) In feces	cc
		(4) In abnormal discharges, such as vomitus, diarrhea, drainage, etc	cc
Total	cc	Total	cc

SALT BALANCE

Of equal importance to the maintenance of water balance is the proper concentration of salts in the body fluids Inasmuch as salt is necessary for the preservation of the osmotic pressure, even a slight imbalance will create a marked disturbance of function A deficient salt intake will give rise to malaise, anorrhexia, vomiting, stupor, drowsiness, and coma; an excessive intake leads to salt and water retention manifested by edema The principal organ concerned with maintenance of a constant concentration of the dissolved salts in the plasma is the kidney In the words of Standard (98), the kidney "is more the custodian of the water-salt ratio than the fluid-solid ratio" Normally 6 to 12 grams of salt are excreted in the urine daily and only 0 5 gram by way of the skin and feces (17)

In order to estimate the patient's electrolytic status, tests should be made to determine plasma chlorid and carbon dioxid-combining power Coller (17), after studying a group of patients with low plasma chlorids, found that the salt requirement could be accurately calculated on the basis of body weight and plasma chlorid level He lays down the following rule "for each 100 mg per 100 cc that the plasma chlorides need to be raised to reach normal (560 mg NaCl per 100 cc) the patient should be given 0 5 gram of salt per kilogram (or 0 2 gram of salt per pound) of body weight For example, if a patient weighing 60 kg is found to have a plasma chloride level of 430 mg per 100 cc and it is desired to raise the plasma chlorides to 580 mg per 100 cc, the patient needs salt as follows $\frac{580 - 430 \text{ mg}}{100 \text{ mg}} \times 0\ 5$ gram/kg $\times$ 60 kg $=$ 45 00 grams of salt Because salt is always lost from the body in isotonic or hypotonic solution, this amount of salt should be given in the form of physiological saline solution, the total volume containing 45 00 grams amounting to 5,294 cc This is best given intravenously at the rate of about 500 cc per hour"

ACID BASE BALANCE

A third factor—by no means the least important—to be considered in the metabolism of the surgical patient is the reaction of the fluid media Many pathologic states tend to alter the normal reaction, or hydrogen ion concentration, of the body fluids These states may be either accidental or incidental to the operative condition, or they may

supervene during or after the operation, due to restricted nutrition, dehydration, circulatory embarrassment, or the effects of the anesthetic agent. Even a slight deviation in the acid base equilibrium from the normal pH 7 4 creates a condition incompatible with life. Thus a pH of 7 results in death from acidosis and a pH of 7.8 causes death from alkalosis.

In order to avoid an acid base imbalance and to counteract its effects if already present, it is of the utmost importance that there should be a clear understanding of the principles underlying the regulation of the normal acid base equilibrium. While a complete description of the physicochemical reactions of the hemoglobin, calcium salts, phosphates, and proteins, together with their complicated "buffer systems" is interesting, it is unnecessary for a comprehension of the pathogenesis associated with acidosis and alkalosis. Only the essential fundamental factors by means of which the blood and tissues maintain their normal reactions will here be given consideration

Tissues Which Control Acid Base Balance

The tissues which control the acid base balance of the body are (1) the blood, (2) the liver, (3) the kidney, (4) the lung and (5) the intestines. These agents act interdependently, if one fails, a strain is automatically thrown upon those remaining, in order to compensate for the deficiency

(1) Blood. Within given limits an excess of acid or alkali is compensated for by the sodium bicarbonate and sodium phosphate in the blood, known as "buffer salts" whose function it is to soak up the excess acid hydrogen or alkali hydroxyl ions and prepare them for their excretion in a less active form through the lung and kidney The following equations will explain the conversion of a strong acid and alkali into weaker ones

$$HCl \text{ plus } NaHCO_3 \text{ equals } H_2CO_3 \text{ plus } NaCl$$
$$NaOH \text{ plus } H_2CO_3 \text{ equals } NaHCO_3 \text{ plus } H_2O$$

The normal acid base equilibrium is maintained by a balance between (a) the free carbon dioxid of the blood acting as a weak acid, and (b) the combined carbon dioxid in the form of sodium bicarbonate, acting as a weak base. Thus the normal reaction of the blood may be expressed by the following formula

$$pH = \frac{\text{carbonic acid}}{\text{sodium bicarbonate}} = \frac{\text{3 vols. per cent in the blood}}{\text{60 vols. per cent in the blood}} = \frac{1}{20}$$

It can be seen from the above formula that the reaction of the blood will be influenced by any alteration in the volume of the carbonic acid or of the sodium bicarbonate radical. In the event of either an absolute increase of acid or a relative increase due to a diminution of the alkali, the above ratio may still be maintained. This condition is known as 'compensatory acidosis." For instance, suppose the normal relationship between carbonic acid and sodium bicarbonate that is, as 3 is to 60

$$\left(\frac{\text{carbonic acid}}{\text{sodium bicarbonate}} = \frac{3}{60}\right)$$

has been changed to 2 is to 40

$$\left(\frac{\text{carbonic acid}}{\text{sodium bicarbonate}} = \frac{2}{40}\right)$$

It will be seen that although the ratio of $\frac{3}{60}$ and $\frac{2}{40}$ is the same, yet in the latter case the total carbonic acid and the total sodium bicarbonate content have been actually reduced. Under such circumstances a further increase in the acid content of the blood or a further reduction in the alkali could not be compensated for and would result in the clinical syndrome of acidosis Conversely, when the alkali is increased but the ratio remains unaltered, the condition is referred to as "compensatory alkalosis" While this state of compensation occasions no symptoms, the patient's reserve is limited, and in the case of a further increase in alkali, such as occurs, for instance, after vomiting, compensation can be brought about only at the expense of a dangerous interference with respiration

(2) **Liver.** As a result of protein metabolism, amino-acids are formed and subsequently deaminized into ammonia, part of which is converted by the liver into urea, and the balance, after it has neutralized the acids formed in the body, is excreted in the urine as salts of ammonia Thus it follows that the more ammonia required to neutralize the acids, the less there will remain for the manufacture of urea This explains the diminished quantity of urea and the increased quantity of ammonia salts in the urine in acidosis.

(3) **Kidney.** Under normal conditions alkali phosphates are converted into acid phosphates and eliminated in the urine. Should there be an excessive acid loss, as occurs when carbon dioxid has been washed out of the lung following overstimulation of the respiratory center, the above-mentioned conversion does not take place, and the alkaline phosphate is excreted unchanged, causing the urine to show an alkaline reaction In the case of a damaged kidney the acid phosphates normally excreted in the urine accumulate in the body and stimulate the respiratory center to expel them This probably explains the polypnea associated with uremia

(4) **Lung.** A slight increase in body acid or a decrease in body alkali tending to upset the normal acid base equilibrium is compensated for up to a certain point by a hyperactivity of the respiratory center As a result of the increased respiratory rate, the excess carbon dioxid in the blood is washed out When the condition is reversed and there is a decrease in acid or an increase in alkali, this protective mechanism works in an opposite direction

(5) **Intestines.** The intestines play a part in the maintenance of the normal acid base equilibrium by excreting alkaline phosphates This is exemplified clinically by the fact that a sharp purgative often forestalls a threatened acidosis

An inability on the part of the above mechanisms to maintain the normal ratio between the acid and base content of the blood results in either acidosis or alkalosis

Acidosis

As previously stated, acidosis is a condition caused by a modification of the normal equilibrium between acids and bases, in which there is either (1) a diminution in the sodium bicarbonate—i.e , combined carbon dioxid (non-gaseous acidosis), or (2) an increase in the carbonic acid—i e , free carbon dioxid (gaseous acidosis)

The factors responsible for this condition are: (a) diarrheal diseases, associated with a loss of basic salts, (b) re[illegible]eases, involving an inadequate excretion of acid products, (c) dehydration [illegible]he tissues become so depleted of water that there is not enough present to [illegible] the normal acid bodies which accumulate, (d) con-

ditions causing anoxemia, in which there is an interference with elimination of acid by way of the lung, (e) defective carbohydrate metabolism as in diabetes, wherein the fats are incompletely oxidized and break up into acids and ketone bodies—notably beta-oxybutyric acid, diacetic acid, and acetone—and soak up the reserve alkali, and (f) starvation, wherein energy can be furnished only by means of the oxidation of body tissues. In the last case the body, under the circumstances, cannot supply an adequate amount of carbohydrates for complete combustion, and therefore intermediary bodies, such as acids and ketones, are formed

The clinical manifestations of acidosis are drowsiness, headache, irritability, nausea and vomiting, and hyperpnea. The urine is scanty and highly acid, with a diminished urea content, an excessive amount of ammonia, and contains ketone bodies. The degree of acidosis may be determined by an estimation of the percentage of carbon dioxid in the alveolar air or by a computation of the carbon dioxid-combining capacity of the blood plasma. Normally, the carbon dioxid-combining power of the blood is between 55 and 80, but in acidosis it is markedly lowered. Values of 30 volumes per cent indicate a severe condition, and values under 20 should cause grave concern

Alkalosis

Alkalosis is a syndrome caused either by an increase in the basic carbonates of the blood or by a decrease in its acid radical. It arises as a result of (1) a diminution in the acid carbon dioxid, as seen in hyperpnea, wherein the carbon dioxid is washed out of the body, or of (2) an increase in the basic carbonates, either following protracted vomiting with its attendant loss of hydrochloric acid, or after the administration of large doses of sodium bicarbonate to individuals with impaired renal function.

The condition is manifested by lethargy, prostration, mental confusion, irritability, and dehydration, symptoms similar to those of acidosis, but the respiratory excursions, instead of being rapid, are slow and shallow, due to an attempt on the part of the body to conserve the carbon dioxid and thus maintain the acid base equilibrium As a result of the deficient oxygenation, the patient is cyanotic. Muscular spasms resembling those associated with tetany and even convulsions may supervene due to a decrease in the ionized calcium in the excessively alkaline blood. The urine is scanty alkaline in reaction, with a diminution of ammonia and chlorids. The blood shows an increased carbon dioxid-combining power, a fall in concentration of plasma chlorids, and an increase in urea and non-protein nitrogen.

MANAGEMENT OF DEHYDRATION AND ELECTROLYTIC LOSS

Choice of Parenteral Fluid

Inasmuch as a loss of fluid from the body is usually associated with an electrolytic imbalance, a deficiency of protein, and a need for supplying caloric energy, obviously the parenteral administration of water alone is not sufficient it may even do harm by further dehydrating the patient. As pointed out by Standard (98) "If a normal subject were to ingest 1 000 c. cm. of distilled water or tap water, the urine flow would rise promptly to from 300 to 500 c. cm. an hour, and within four hours the excretion would include 1,000 c. cm. over and above the normal excretion for that time. Theoretically it would appear that the subject should again be in his original state of

water-salt balance Actually he is not He drank distilled water and excreted urine No matter how dilute that urine may have been the diuresis carried with it, 'washed out,' a certain amount of sodium chlorid In order to restore his original salt-water ratio either the salt must be replaced or the body loses an amount of water the equivalent of the salt loss It will thus dehydrate itself in order to keep its water-salt ratio constant Peters [87] points out that the ultimate result of such water diuresis is the sweeping out of endogenous salt and interstitial water. The subject loses weight at the expense of extracellular fluid" (fig 181).

In view of the above, it is essential that each patient be analyzed for a determination of his specific deficiency, so that the required element may be replaced with the fluid The necessary tests include an estimation of blood chlorids, carbon dioxid-combining power, sugar, and protein

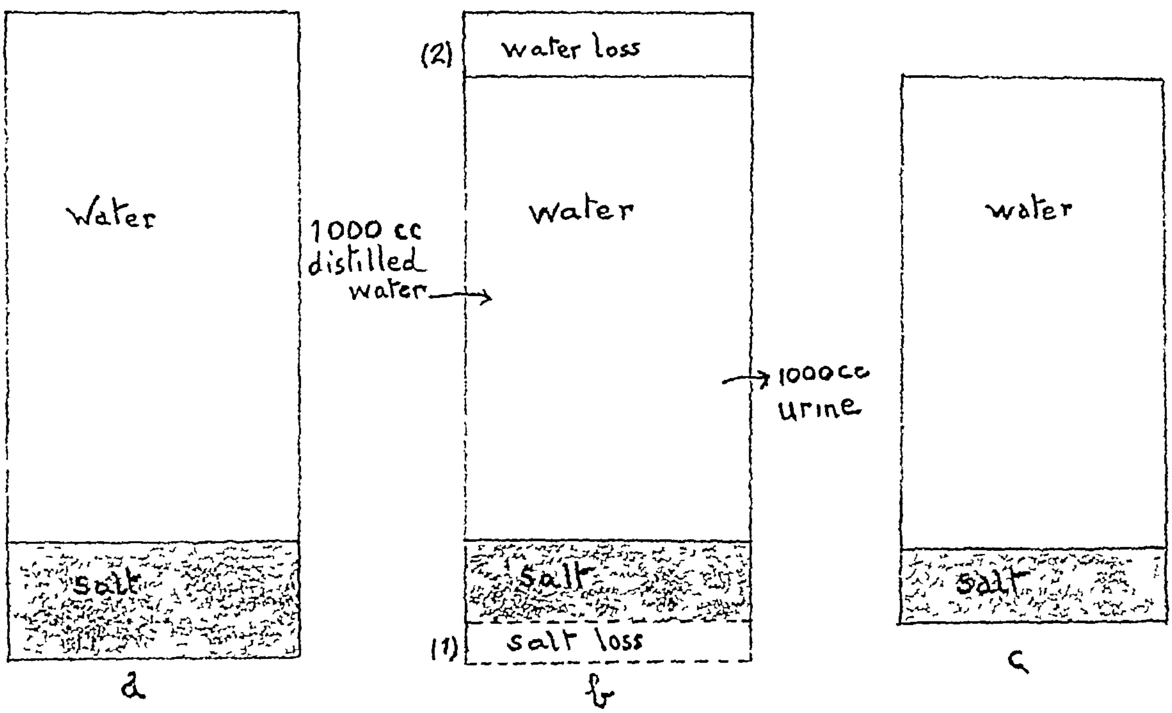

FIG 181 Diagram, illustrating production of dehydration by ingestion of distilled water *a*, normal water-salt ratio *b*, effect of ingestion of 1000 cc of distilled water and its excretion as 1000 cc of urine. *1* shows endogenous salt washed out in urine *2* shows water loss to restore normal water-salt ratio *c*, final effect of water and salt loss For details, see text (Standard)

An associated electrolytic deficiency is best replaced with a physiologic sodium chlorid solution Owing to its isotonicity, it is retained in the circulation and helps maintain the osmotic pressure of the body fluids, and by its sodium chlorid content it serves to uphold the acid base equilibrium To supply caloric energy, isotonic solutions of glucose are employed The glucose furnishes the energy, and the water, not being isotonic, is eliminated To replace a protein loss, such as occurs in hemorrhage, albuminuria, extensive burns, and massive purulent discharges, recourse must be had to blood transfusion. Frequently the nature of the deficiency is such that it becomes advisable to alternate or combine two or more solutions For example, the fluid requirement may be 3,500 cc If this amount is given in the form of an 0 85 per cent sodium chlorid solution, the total quantity of sodium chlorid injected must necessarily equal 31 5 grams—an amount greatly in excess of the normal daily need of 15 grams—

and, obviously, retention of salt and a consequent edema must follow Under such circumstances, a supplementary administration of an isotonic glucose solution frequently solves the problem. The glucose is completely metabolized and the remaining water combines with the excess salt and is eliminated, the body thus being steered between dehydration on the one hand and circulatory edema on the other Coller, Dick, and Maddock (18) report that in a group of sick patients given 5 per cent glucose in normal salt solution all retained water and gained weight. When the intravenous solution was changed to 5 per cent glucose in distilled water, diuresis resulted and the retained water was given off (fig 182)

Salt Solution

Isotonic sodium chlorid solution—that is, an 0 85 per cent solution of sodium chlorid in water—is the one most commonly employed for the replacement of fluid and electro-

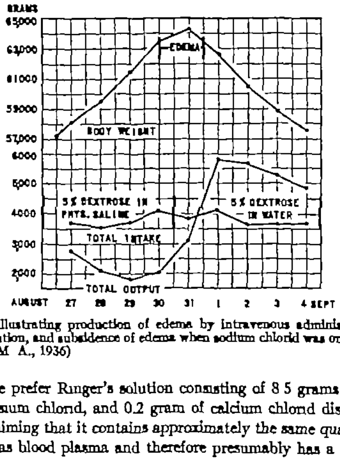

FIG 182. Chart, illustrating production of edema by intravenous administration of 5 per cent dextrose in saline solution, and subsidence of edema when sodium chlorid was omitted. (Coller Dick, and Maddock, J A. M A., 1936)

lytic losses. Some prefer Ringer's solution consisting of 8 5 grams of sodium chlorid, 0.3 gram of potassium chlorid, and 0.2 gram of calcium chlorid dissolved in a liter of distilled water, claiming that it contains approximately the same quantity of potassium and calcium ions as blood plasma and therefore presumably has a beneficial effect on the heart muscle.

These solutions, in addition to replacing fluid and electrolytic losses, are capable of correcting the frequently associated acid base imbalance. In cases of acidosis the body by means of a selective activity, will retain the sodium of the solution and discard the chlorin, and conversely, in alkalosis it will retain the chlorin and discharge the sodium. Peters and Van Slyke (88) assert that saline solution replaces not only chlorins but bicarbonates as well, as shown in the following equation

NH_4HCO_3	plus $NaCl$ =	NH_4Cl	plus	$NaHCO_3$
(formed in kidney)		(excreted in urine)		(retained in body)

Isotonic salt solutions are also of value in replacing blood volume lost through shock and hemorrhage, but since they remain in the blood stream for only a short time, they should be used for this purpose only in emergencies and in the absence of a blood donor Some advocate the use of hypertonic solutions for the reason that by virtue of their osmotic pressure they mechanically draw additional fluid into the blood vessels, but even these solutions pass out of the capillaries as soon as dilution takes place

While the value of saline solutions in selected cases is indisputable, and recourse to them is often a life-saving procedure, nevertheless, when used indiscriminately, they are not without danger. In the case of patients who have not lost salt but merely require water replacement, the salt of the solution is retained in the tissues, and the excess may eventually lead to edema, while in those requiring salt the administration of too great a quantity of the solution may likewise lead to salt retention In either case, should the kidney be diseased, the excess may precipitate a crisis To obviate the risk of edema, the plasma chlorids should be estimated daily, and when they approach 525 to 560 mg per 100 cc , salt should be withheld and the fluid intake continued as a 5 per cent dextrose solution While in the case of hemorrhage salt solution serves temporarily to raise the blood volume, it may cause harm by diluting the plasma and by lowering still further the percentage of corpuscles in the circulation It must be used with caution in the presence of degenerative changes in the heart, kidney, and lung, since the volume of the liquid introduced puts a strain on these organs and may lead to circulatory collapse and edema of the lung (75)

If salt solution is used, the sodium chlorid must be pure and sterile and the water triply distilled. Sterile solutions in sealed containers are on the market and are advised in cases where facilities for sterilization are not adequate

Glucose Solution

Glucose solution administered parenterally finds its ideal application in patients suffering from dehydration and caloric deficiency, without electrolytic loss. (1) It is an ideal hydrating agent Unlike salt solution, it is not retained in the tissues, and in the process of its elimination it provides fluids for urine formation and water for vaporization, each gram of glucose furnishing 0 6 cc of water of oxidation. (2) It supplies readily utilizable energy and thus protects the body against excessive catabolism of its tissues, each gram of glucose liberating 3.75 calories Unlike fat and protein, it makes no demands on the metabolic function of the liver Thus, introduced parenterally, it is capable of rendering the patient independent of the activity of his intestinal tract for several days Unfortunately, however, glucose solution given parenterally cannot supply the total nutritional need, since if given in sufficient volume or concentration to satisfy this requirement it would embarrass the heart or spill over in the urine The body requires 25 calories per kilogram of body weight to furnish the energy necessary for basal metabolism Thus a person weighing 75 kilograms has need of 1,875 calories daily The amount of glucose supplied by the administration of 3,500 cc. of a 5 per cent solution is but 175 grams, and as 1 gram of glucose furnishes 3 75 calories, the total intake under these circumstances will be only 656 calories, an amount obviously inadequate (3) Glucose combats ketosis in cases of starvation It has been estimated that the glycogen reserve in the liver becomes exhausted in the course of 18 hours. After this period the necessary carbohydrate must be drawn from the tissues

at the expense of the body economy (Physiologists state that 58 per cent of the body proteins and 10 per cent of the body fat can be converted into carbohydrates.) In time this deficiency of carbohydrates results in an incomplete oxidation of fats, and the end products of deficient fat metabolism, notably beta-oxybutyric and diacetic acid, accumulate and pave the way for acidosis. In starvation then, the parenteral administration of glucose solution will avert such disastrous consequences by permitting of the complete oxidation of fats.

The strength and quantity of the glucose solution will depend upon the water requirement, caloric need and individual tolerance of the patient. A 5 per cent solution in water is the concentration of choice, as it is isotonic with the blood, does not overtax the kidney, and produces little reaction if it leaks into the subcutaneous tissues around the needle. Hypertonic solutions of glucose of 10 to 20 per cent or more are reserved for dehydrating purposes—for instance, to relieve edema of the lung or brain (p 542) They raise the blood pressure by abstracting water from the tissues and adding it to the blood and by virtue of this and the hyperglycemia they produce, have a strong diuretic effect. In this concentration however, they must be used with caution, as they have a tendency to "spill over in the urine," and in addition may cause considerable local reaction if the fluid accidentally escapes from the needle into the subcutaneous tissues. Furthermore, their use involves the risk of a possible thrombosis at the site of injection

For ordinary purposes glucose solution is given intravenously as a 5 per cent solution in the proportion of 20 cc. per pound of body weight, or as a 10 per cent solution, 10 cc. per pound of body weight. The greater the caloric need, the nearer the solution should approach a 10 per cent concentration In any case, it should be delivered slowly otherwise the blood-sugar may be raised above the renal threshold and be lost in the urine. Woodyatt and his associates (117, 31) determined that the physiologic rate for a normal adult is between 0.8 and 0 9 gram per kilogram of body weight per hour If the rate exceeds these figures, glycosuria results, and since 20 cc. of water are required for the excretion of a gram of sugar, such an increase may aggravate rather than relieve the state of dehydration. On the basis of Woodyatt's figures, Bassett (3) estimates that in a patient weighing 70 kilograms the permissible volumes of concentration and the rate of administration are as follows 50 per cent solution 125 cc. per hour, 25 per cent solution, 250 cc. per hour, 10 per cent solution 650 cc. per hour, and 5 per cent solution, 1,300 cc. per hour He believes that 750 cc. per hour is the maximum excretory rate to which the healthy kidney can be subjected for any considerable length of time without the danger of overloading Fantus (33) asserts that "a 10 per cent solution [of glucose] can be introduced at the rate of 500 cc. an hour before the sugar tolerance of the average individual is overcome, as evidenced by leakage of sugar in urine" For the sake of safety then not less than 45 minutes should be consumed in the introduction of 500 cc. of a 5 per cent solution of glucose

When indicated, insulin may be added to the solution In the case of non-diabetic patients its use is reserved for hypertonic solutions. In diabetic patients 10 to 15 units are injected hypodermically 10 minutes after the beginning of an infusion of 1,000 cc. of a 10 per cent solution of glucose and a similar dose is given at the end of the infusion.

As has been said above glucose solution cannot replace an electrolytic loss. Therefore, where salt replacement becomes necessary, as commonly occurs in cases of dehy

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protein has been reduced to 5.5 ±0.3 per cent, and that latent edema may occur even at a higher level. According to Bell (8), a loss of serum albumin lowers the osmotic pressure more than does a corresponding loss of serum globulin This fact he attributes to the smaller molecular formula of the albumin (67,500) as compared with that of globulin (103,800)

In shock and hemorrhage when the fall in blood pressure has deprived the heart of sufficient blood to pump, a blood transfusion is the best means of restoring the lost volume. In addition it furnishes oxygen-carrying erythrocytes and thus relieves the anoxemia associated with hemorrhage. Other fluids such as isotonic salt or glucose solutions, are of only temporary value for this purpose, since they cannot be retained in the circulation for more than a limited period

Finally transfusion is of inestimable value as a prophylactic measure when the general condition of the surgical patient is unsatisfactory, and when the operation must of necessity be prolonged By recourse to this expedient, surgery, even in the case of a poor risk, can often be carried to a successful conclusion—for instance, in patients suffering from blood diseases, like hemophilia, purpura and anemia, from jaundice, from pyogenic infections, especially those associated with hemolysis and from toxic disorders such as carbon monoxid and metallic poisoning It has been estimated that the transfusion of a pint of blood in an adult will increase the total hemoglobin content by 10 per cent.

Katzin (57) summarizes the indications as follows

Reduction of blood volume
- Hemorrhage
- Shock

Inefficient blood formation
- Sepsis
- Benzol arsenic, sulphanilamide, radium X ray etc.
- Aplastic anemia

Excessive blood destruction
- Infections
- Hemolytic organisms
- Toluene phenylhydrazine lead burns etc.

Immune properties of transfused blood
- Measles
- Scarlet fever
- Other infections

Blood dyscrasias
- Icterus gravis
- Hemorrhagic diathesis of newborn
- Erythroblastic anemia—Cooley s
- Other anemias

Other blood deficiencies
- Purpuras
- Hemophilias
- Jaundice etc.

Alteration of hemoglobin
- Carbon monoxide
- Methemoglobinemia
- Sulphemoglobinemia

Supportive treatment
- Prophylactic in surgery
- Infections
- Ulcerative colitis
- Dehydration—infancy burns, etc.
- Neoplasms, etc.

Donor If there is a probability of the need of blood transfusion one or more donors should be examined properly grouped and matched, and kept in readiness, so that there will be the least possible delay should their services be required If the use of two donors is anticipated, they should be matched against each other as well as against the patient. In case the patient is to receive more than one transfusion from the same donor the routine examination and matching must be repeated before each transfusion

dration, a 2 5, a 5, or a 10 per cent solution of glucose is dissolved in an 0 85 per cent solution of sodium chlorid The carbohydrate furnishes caloric energy and combats ketosis, the water compensates for the fluid loss, and the salt re-establishes the electrolytic pattern

For purposes of infusion it is imperative that only chemically pure glucose be used and that it be dissolved in triply distilled water In the process of sterilization, heat has a tendency to caramelize glucose, hence, any solution which is not crystal-clear should be discarded Glucose solution is marketed in large hermetically sealed glass containers, the ends of which taper out into small tubes Immediately before use the lower end is broken off and connected with the rubber tubing.

Blood

According to Warthen (111), the first recorded blood transfusion was administered to Pope Innocent VIII in 1492 But the results of this and of subsequent administrations were so unfortunate that the practice soon fell into disuse With the discovery by Harvey in 1616 of the circulation of the blood new interest was aroused In 1666 Denis, physician to Louis XIV, reported the transfusion of blood from a lamb to a boy, and a statement concerning the patient's reaction has recently been quoted by Chapman (14)· "he grows fat visibly and in brief is a subject of amazement to all those who know him and dwell with him " According to Keith (59), Blundell in 1824 successfully transfused whole blood from one human being to another, and in 1835 Virchow suggested the use of defibrinated blood Landsteiner (62) and Shattuck in 1900 demonstrated the presence of iso-agglutinins in the blood This disclosure led to the observations of Jansky (1907) and Moss (80) (1910), who classified all persons in accordance with their blood type, thus paving the way for a satisfactory means of averting unfavorable reactions to blood transfusions and extending the therapeutic possibilities of the procedure It was soon found that blood grouping alone was not entirely sufficient to insure against reactions, and so the expedient of matching the donor's cells and the recipient's serum was added in the selection of the donor The succeeding years brought numerous improvements in the technical details to simplify the process and reduce the time required Kimpton and Brown (60) in 1913 developed their tube, and in the same year Lindeman (68) described his method with the use of multiple syringes, in 1915 Percy (86) introduced his paraffin-coated tubes, and Unger (108) described his transfusion apparatus, in 1914 Agote (1) evolved the method of citrated blood transfusion, although it is to Lewisohn (65) that the actual credit for its popularization belongs Yudin (118) in 1936 published a report of successful transfusion of conserved refrigerated blood obtained from cadavers Blood transfusion is at present more frequently resorted to than ever before, owing to the simplification of the technic and the greater protection afforded the patient against untoward reactions by the more sensitive serologic tests

Indications for Blood Transfusion A deficiency of blood proteins must be made up, since proteins by virtue of their osmotic tension serve to hold fluid within the vessels and thus maintain the blood volume The only way to restore protein losses is by means of blood transfusion The normal amount of plasma proteins is 7 grams per 100 cc. of blood, of which serum albumin constitutes 4.5 grams and serum globulin 2.5 grams. Moore and Van Slyke (79) have shown that edema begins when the total

protein has been reduced to 5.5 ±0.3 per cent, and that latent edema may occur even at a higher level. According to Bell (8), a loss of serum albumin lowers the osmotic pressure more than does a corresponding loss of serum globulin This fact he attributes to the smaller molecular formula of the albumin (67,500) as compared with that of globulin (103,800)

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Relatives and friends are usually the first to be called upon to serve as donors, and preference is given to persons between the ages of 20 and 30, with prominent cubital veins A short history is taken and a physical and laboratory examination made, in order to rule out those with allergic propensities or communicable diseases, such as tuberculosis, malaria, and syphilis The number of red blood cells should not be less than 4,000,000 per cubic millimeter, and the hemoglobin content not below 80 per cent. A fasting donor is preferable, since the amount of foreign protein in the blood of such an individual will be minimal Tests are then conducted to determine the compatibility of the donor, since the use of incompatible donors will result in serious reactions, manifested during the course of the transfusion by severe headache, distress, nausea, and vomiting, and later by repeated rigors, rise in temperature, fall in blood pressure, hemoglobinuria, precordial pain, convulsions, collapse, and perhaps death Even though the blood of donor and recipient be compatible, a slight general reaction is occasionally encountered, taking the form of chills, headache, pain in the lumbar region, rise in temperature, nausea, vomiting, dizziness, sweating, and an urticarial rash, which lasts for a few hours, and then spontaneously disappears The cause of these reactions is unknown, and has been attributed, aside from incompatibility, to the use of contaminated instruments, the administration of citrate solutions, and the presence of foreign proteins in the donor's plasma

Tests for Compatibility. Two tests are essential for the proper selection of a compatible donor (1) An indirect test, and (2) a direct test

(1) *Indirect Blood Grouping Test* By means of this test the blood group to which both recipient and donor belong is determined by a comparison of the donor's and recipient's corpuscles with a known serum. Known sera from Groups II and III may be purchased from the laboratory in capillary tubes A suspension of the donor's red blood cells is prepared in the following manner. Two to 3 drops of blood obtained from the ear are mixed with 3 cc of a 1 5 per cent sodium citrate in physiologic salt solution On each end of a glass slide is placed one drop of this suspension To the drop on the right side one drop of Group II serum is added, and to the drop on the left side one drop of Group III serum The slide is then appropriately labeled and examined under low power for the detection of agglutination If at the end of 15 minutes no agglutination has taken place, the test is considered negative The same procedure is repeated with the patient's blood

Levine (64) conducts the test thus First, the grouping sera are selected with a view to potency, absence of pseudo-agglutination, and absence of atypical agglutinins Then a 5 per cent suspension of blood is prepared "by allowing one drop of blood to fall into 2 cc of saline and shaking " A small sample of the patient's blood is "allowed to clot or else be defibrinated After centrifuging, the serum is separated and saved for the direct matching From the clot a small amount of blood may be suspended to make a 5% cell suspension to be used in the grouping The actual test may be performed either on an open slide or in small test tubes In any event, one capillary drop of each of the two sera is mixed thoroughly with one drop of 5% suspension of cells If the tests are done on an open slide, the reactions are complete after one minute, depending upon the agglutinability of the cells Reactions negative to the naked eye should be observed for about 5 minutes and confirmed by examination under the low power lens

'The well-known scheme for the diagnosis of the group is given below

	Agglutination Reaction with Cells of Groups			
	O	A	B	AB
Serum of group A (anti-B)	—	—	—	—
Serum of group B (anti A)	—	—	—	—"

In the case of emergency a known donor belonging to Group O International or Group I Moss or Jansky may be used. Ten cubic centimeters of the donor's blood are injected into the vein of the recipient, and if no reaction occurs in 1 minute, 20 cc of blood are introduced, after which, if no reaction occurs in 2 minutes, the transfusion proceeds.

(2) *Direct Blood Grouping Test* (*Blood Matching*) Although patient and donor may belong to the same group, the blood cells of the two individuals will not necessarily be compatible, and another test is necessary in which the cells of the donor are matched against the serum of the recipient. This test provides a check on the grouping and also excludes the possibility of a sub-group reaction. A few cubic centimeters of the recipient's blood are collected in a clean centrifuge tube and centrifuged until a clear supernatant serum forms. A drop of the patient's serum is then placed on a cover-glass slip A drop of the citrated saline suspension of the donor's cells is added and the mixture is inverted over a hanging drop slide. If no agglutination occurs after 45 to 60 minutes, the donor's blood may be considered compatible. Some advise as an additional precaution that the test be repeated with the recipient's cells and the donor's serum, but this seems unnecessary, since the donor's blood is so rapidly diluted upon entrance into the recipient's blood stream that it could have but little effect on the recipient's cells.

Levine (64) prefers the test tube method. "Two drops of recipient's serum are mixed in a small test tube with two drops of a 5 per cent suspension of donor's cells to this mixture are added two drops of saline which serve (1) to wash down traces of reagents adhering to the sides of the tube and (2) as an added precaution against the effects of pseudo-agglutination which disappear on slight dilution of the serum. The tube is now centrifuged at low speed for 1 minute and the reading is made by gently shaking the bottom of the tube, thus resuspending the sedimented cells. Maximum reactions are rapidly obtained. In the case of negative reactions, the sedimented cells are not so readily resuspended. Reactions negative to the naked eye must be checked microscopically by withdrawing with the aid of a thin glass rod, some of the resuspended mixture on to a glass slide"

Choice of Blood. Either whole or modified blood may be used. (1) Whole blood has the advantage of retaining its original characteristics, inasmuch as nothing has been added to alter its properties, and there is less likelihood of its being contaminated or chilled in the interval between its collection and introduction Its administration, however, necessitates a more elaborate equipment and experienced assistants, in order to prevent its clotting, and because of this difficulty it has been largely supplanted by modified blood

(2) Modified blood is that which has been rendered non-coagulable by the addition of sodium citrate. It is easy to administer, may be kept in readiness for 10 to 12 days

Relatives and friends are usually the first to be called upon to serve as donors, and preference is given to persons between the ages of 20 and 30, with prominent cubital veins A short history is taken and a physical and laboratory examination made, in order to rule out those with allergic propensities or communicable diseases, such as tuberculosis, malaria, and syphilis The number of red blood cells should not be less than 4,000,000 per cubic millimeter, and the hemoglobin content not below 80 per cent A fasting donor is preferable, since the amount of foreign protein in the blood of such an individual will be minimal Tests are then conducted to determine the compatibility of the donor, since the use of incompatible donors will result in serious reactions, manifested during the course of the transfusion by severe headache, distress, nausea, and vomiting, and later by repeated rigors, rise in temperature, fall in blood pressure, hemoglobinuria, precordial pain, convulsions, collapse, and perhaps death Even though the blood of donor and recipient be compatible, a slight general reaction is occasionally encountered, taking the form of chills, headache, pain in the lumbar region, rise in temperature, nausea, vomiting, dizziness, sweating, and an urticarial rash, which lasts for a few hours, and then spontaneously disappears The cause of these reactions is unknown, and has been attributed, aside from incompatibility, to the use of contaminated instruments, the administration of citrate solutions, and the presence of foreign proteins in the donor's plasma

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in a refrigerator at 40°F and transported for a distance if necessary, patient and donor need not be in contact for its introduction, and it does not seem to prolong the coagulation time of the patient's blood On the other hand, there is some evidence to indicate that it has a destructive effect on the complement, thus reducing the phagocytic and opsonic power of the blood, and that it is more likely to produce general reactions

Other types of blood for transfusion purposes have been suggested, among them being placental blood, retroplacental blood (106), extravasated blood, and cadaver blood Goodall and his associates (42) point out that placental blood is available in unfailing quantities, is rich in red cells, free from allergic reactions after 48 hours, and can be preserved for as long as 60 days by the addition of a solution proposed by the Moscow Institute of Hematology and consisting of 7 grams of sodium chlorid, 5 grams of sodium citrate, 0 2 gram of potassium chlorid, 0 004 gram of magnesium sulphate and 1,000 cc of twice distilled water

Shamov (95) and Yudin (118) advocate the use of stored blood procured from persons who have died suddenly of coronary thrombosis, or as victims of electrocution or accident, and point out that the erythrocytes in the blood of a cadaver retain their vitality for 10 to 11 hours and are capable of functioning as well as those of normal blood Moreover, in many cases an anticoagulant is unnecessary, for while blood withdrawn from a body within the first few hours after death rapidly coagulates, it reliquifies in $\frac{1}{2}$ to $1\frac{1}{2}$ hours after its removal The writers state that from each cadaver 2,000 to 3,500 cc can be obtained After making the necessary serologic and bacteriologic tests they preserve the blood at a temperature of 4°C They find that cadaver blood is as satisfactory for purposes of transfusion as that obtained from live donors They advise, however, that the blood be used within 10 days after withdrawal, because of the increasing fragility of the cells

In a recent editorial of the *Journal of the American Medical Association* (105) the advantages of cadaver blood are summarized as follows "(1) The amount of blood that may be obtained from a single donor is large, (2) it does not have to be paid for, (3) because of fibrinolysis which takes place in the blood of patients dying a sudden death, there is no necessity for adding sodium citrate solution, (4) the number of reactions is markedly diminished because of the absence of conserving fluids, (5) the Wassermann reaction is performed on the blood which is to be transfused, while the possibility of syphilis in a living donor is not always excluded, and (6) the necropsy which is performed on the cadaver before its blood is accepted guarantees the innocuousness of the blood, since it offers the opportunity of examining the donor for signs of tuberculosis, malaria, septic foci and secondary signs of syphilis The method presents certain technical difficulties, the principal one of which is the tendency for the corpuscles to sedimentate and block the drip bulb Marriott and Kekwick (73) have overcome this difficulty by bubbling a continuous stream of filtered oxygen through the blood, thus accomplishing a continuous stirring Another difficulty is the not infrequent occurrence of phlebitis in the arm According to Yudin, the introduction of 0 5 liter of blood raises the hemoglobin of an adult by 9 to 10 per cent Gravely exsanguinated patients may be given the first liter of blood in fifteen or twenty minutes However, the tempo of transfusion after that must be slowed It is not advisable to raise the hemoglobin content more than 10 per cent every four hours This concerns particularly patients who are not bleeding and patients with sclerosis and hyper-

tension. Ordinarily, from forty to forty five drops of blood is transfused every minute, or from 100 to 150 every hour Doses as high as 6 liters may be given in the course of two or three days'

Recently the use of stored blood obtained from patients in need of therapeutic venesection or from healthy donors has been recommended The blood is collected in a 2.5 per cent sodium citrate solution and stored at 2°C in glass-stoppered bottles. Such blood may be kept without danger of hemolyzation for as long as 2 weeks. Immediately before its administration it is warmed to the body temperature. Fantus (34) at the Cook County Hospital, Chicago, has established a so-called 'blood bank' to which all members of the staff contribute blood taken from patients under their care. The bank furnishes (1) whole blood, (2) erythrocyte suspension, (3) non specific human serum, and (4) convalescent serum, and the staff makes the desired withdrawals as the particular needs arise.

Methods have been suggested for the preservation of blood in a desiccated form called lyophile serum (30 38, 81) It is prepared by being subjected to rapid freezing and dehydration under a high vacuum so that the protein and antibody titers remain

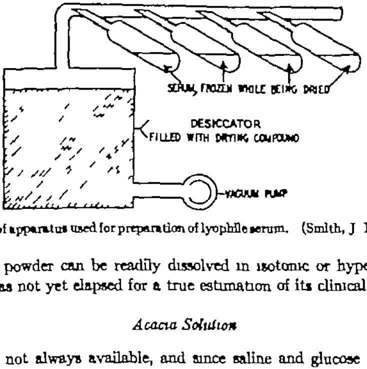

FIG 183 Diagram of apparatus used for preparation of lyophile serum. (Smith, J Iowa M Soc. 1939)

unaltered. The powder can be readily dissolved in isotonic or hypertonic solutions. Sufficient time has not yet elapsed for a true estimation of its clinical value (fig 183)

Acacia Solution

Since blood is not always available, and since saline and glucose solutions do not remain in the vascular system for any length of time, other fluids of a more retentive nature have been sought for the treatment of shock and hemorrhage. Bayliss (5) during the World War first suggested the use of gum acacia as a substitute for blood. He advised 6 grams of acacia to a liter of normal salt solution, as he found that in such a proportion it has a viscosity and osmotic pressure similar to that of the blood plasma. Owing to its colloidal nature, this solution leaves the vascular system very slowly and therefore tends to maintain the blood volume for a longer time than either normal salt or glucose solution However in spite of its well-known power of holding fluid in the blood vessels, some believe that acacia is not free from danger It is said to be injurious to the liver and kidney by clogging the capillaries to interfere with the normal gaseous exchange of the erythrocytes and to have a tendency to produce

alarming reactions (102) These ill effects of the solution have been attributed to its use in an impure or improperly prepared state Today preparations of acacia may be obtained in pure form in ampules The Mayo Clinic reports that in a series of 3,000 infusions of this type given between 1926 and 1932 there was only one unfavorable mild allergic reaction

While acacia is not as effective as blood in elevating the blood pressure, nevertheless, in cases of emergency, when blood is not at once available, it will best serve the immediate purpose It is ordinarily administered in amounts of 450 cc of a 6 per cent solution

Solution	Character	Method of Administration	Indication	Dosage, 24 hours per kilogram
0 9 NaCl physiologic salt	Isotonic neutral in vivo yields excess of Cl	Protoclysis, hypodermoclysis, intravenous infusion	Dehydration with or without acidosis or alkalosis	50–100
5% glucose	Isotonic neutral in vivo yields free H_2O	Same as above	Oliguria, ketosis, carbohydrate lack	40–80
5% glucose with 0 9 NaCl	Hypertonic neutral solution	Intravenous	Dehydration, ketosis	50–100
10% glucose	Hypertonic neutral solution	Intravenous	Severe ketosis, carbohydrate lack	20–40
5% glucose	Hypertonic neutral solution	Intravenous	Increased intracranial pressure	5–10
5% sodium bicarbonate solution	Hypertonic alkaline	Intravenous	Severe acidosis supplementary to physiologic salt solution	5–10
1 8% sodium lactate solution	Isotonic neutral in vitro, produces alkali in vivo	Hypodermoclysis intravenous	Severe acidosis supplementary to physiologic salt	10–20
6% acacia in 0 9 NaCl	Isotonic, osmotic pressure of colloids similar to that of plasma proteins	Intravenous infusion	Shock and hemorrhage, temporary substitute for transfusion	10–20
Blood, whole or with 0 25% sodium citrate		Intravenous infusion	Hemorrhage, shock, anemia, hemorrhagic diseases, infectious diseases, deficient plasma proteins	10–20

The above table used at the Massachusetts General Hospital gives a practical summary of the solutions employed, their nature, method of administrations, indication, and dosage

Avenues of Administration

There is no difference in the manner of utilization of fluids by the body, whether they be taken by mouth or introduced parenterally

Oral Route

If the patient is conscious and the stomach has not lost its retentive power, fluid is preferably given by mouth. This is the most natural and physiologic avenue, and

no limit need be placed on the amount since there is no danger that edema will result from the ingestion of an excess quantity. Patients who are potentially or actually dehydrated should be encouraged to partake freely of fluids in the form of hot water, albumin water, milk, and glucose solution. The latter can usually be tolerated in large quantities, the excess being stored in the liver for later use. If the stomach has lost its retentive power, a convenient method for the administration of fluid is by means of a duodenal tube connected with a reservoir which constantly feeds the necessary supply.

Hypodermoclysis

By the introduction of fluids subcutaneously it is possible to supply a limited need for a short time, but owing to the associated discomfort, the uncertainty of absorption, and the danger of infection and sloughing, this method has largely given way to that of intravenous infusion which overcomes most of these disadvantages. Cabot (13) believes that the objectionable features of this method of administration are largely due to faulty technic and not to the method itself and claims that "the use of multiple small caliber needles would successfully introduce large quantities of salt solution or 5 per cent glucose without discomfort to the patient."

The apparatus comprises an infusion container to which is attached a rubber tube leading to a Y-shaped glass connection, to each limb of which is attached a rubber tube carrying an aspirating needle (fig 184a). In choosing the site for hypodermoclysis care should be taken not to inject the fluid in the vicinity of large vessels, nerves, or joints. Fatty tissue should also be avoided, as its limited power of absorption may cause distension and discomfort. Kolodny recommends the lateral aspect of the thigh and introduces the needle in such a way that it lies on the fascia lata. The most desirable location is probably the axilla along the pectoral muscle, although in the case of women the submammary region will sometimes be found more convenient. The selected area is sterilized and draped, a procain wheal is raised (p 412), and the hypodermoclysis needles inserted with the solution already flowing, the needles being kept in place by strips of adhesive tape. In order to obtain the required pressure the container is placed 1 meter above the level of the patient. The solution must be sterile, isotonic with the blood, and maintained at a temperature of 120°F. During the injection the area is inspected at frequent intervals to detect any obstruction in the flow or any undue distension. If the solution is being delivered too slowly or the flow becomes impeded, the position of the needle should be changed; conversely, if it is entering the tissues too rapidly, as evidenced by distension, the rate of flow should be decreased, in order to avoid the possibility of sloughing of the tissues.

Proctoclysis

If fluid cannot be introduced by mouth, another route that may be chosen is the rectal one, although usually the reversed peristalsis which contraindicates its oral administration also prevents its retention by the rectum. However, if rectal administration is resorted to, the fluid may be given in the form of tap water, as an isotonic sodium chlorid solution, or as a 5 to 10 per cent glucose solution, the choice depending upon the patient's needs. There is some question as to the ability of the colon to absorb glucose. Certain investigators believe that only the water content

of the glucose solution is absorbed, inasmuch as they have been able experimentally to recover the entire amount of glucose from the bowel washings McNealy and

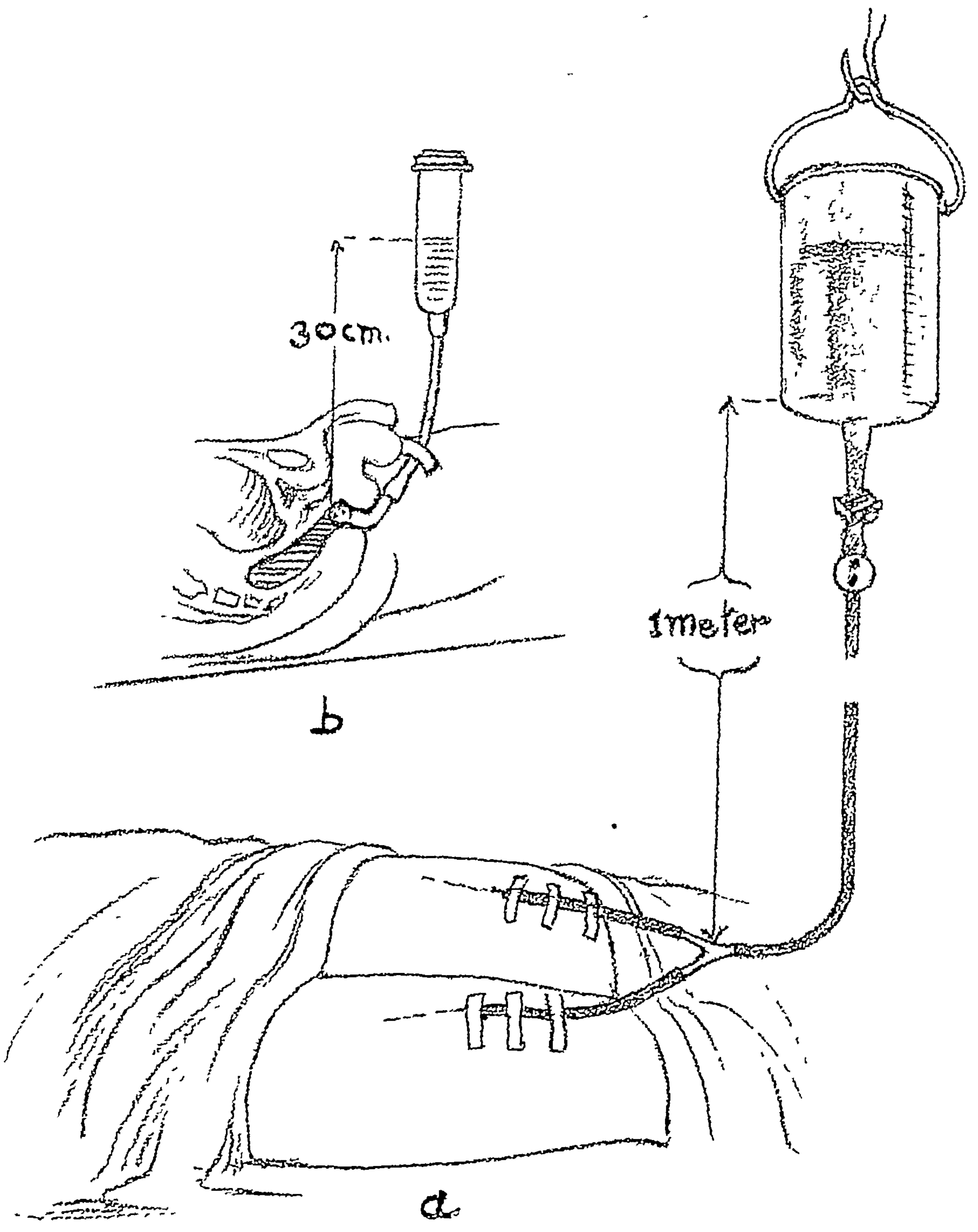

FIG 184 Apparatus for parenteral and rectal administration of fluid *a*, hypodermoclysis apparatus Infusion container with rubber tube leading to Y-shaped glass connection, to each arm of which is attached rubber tube carrying hypodermoclysis needle Container placed 1 meter above patient, and needles held in place by adhesive tape strapped across rubber tubes (Bailey) *b*, proctoclysis apparatus Infusion container with rubber tubing leading to No 32 French catheter and equipped with glass drip bulb and adjustable clamp

his associates (77) are convinced that glucose is absorbed by the colon only when the ileocecal valve is incompetent. Another possible disadvantage in the rectal intro-

duction of this solution is the liability of the unabsorbed glucose to undergo fermentation which may cause irritation of the colon and lead to expulsion of all liquids given subsequently by rectum thus destroying a valuable avenue of fluid administration.

Solutions may be administered rectally in one of two ways (1) As a retention enema. With the patient in Sims position, 250 cc. of normal salt solution or 5 per cent glucose solution are allowed to gravitate slowly into the rectum through a funnel and tube. The injection may be repeated at 4-hour intervals if no irritating symptoms arise. (2) As a continuous or drip enema delivered through a #32 French catheter attached to a container by means of a rubber connecting tube, the apparatus being equipped with a glass drip bulb and an adjustable clamp to regulate the flow (fig 184b) A convenient container is an inverted bottle with a cork containing two holes, one connected with the tube carrying the liquid into the rectum and the other holding a glass tube which is turned up to act as an air valve The container is placed 30 to 45 cm above the level of the patient, and the tip of the tube is inserted for 5 cm. beyond the sphincter The temperature of the fluid in the container is maintained at 120°F and the flow is regulated to 30 to 40 drops per minute, thus 120 to 150 cc are delivered hourly In order to prevent rectal irritation, the quantity of fluid administered at one time should be limited to 1,000 cc.

Intraperitoneal Route

By way of the intraperitoneal route it is possible to introduce physiologic salt solution glucose or even whole blood, but this method is rarely used because of the danger of infection and trauma to the peritoneum and viscera. Siperstein and Sansby (96) inject citrated blood strained through sterile gauze into the peritoneal cavity by means of a glass syringe and a spinal puncture needle. Grulee (44) recommends this route for blood transfusion in infants

Intravenous Route

Intravenous administration is generally accepted as the most efficient method for both rapid and slow introductions of parenteral fluid, whether the purpose be to relieve dehydration, restore the electrolytic pattern, promote diuresis, dilute toxins, provide caloric energy or raise the blood volume. This procedure, however, is not without danger since the direct introduction of a large volume of fluid into the blood vessels may embarrass the heart. For this reason it should be used with caution in the presence of congestive heart failure, arteriosclerosis, hypertension, pulmonary edema, and kidney damage. Furthermore, it sometimes occasions systemic reactions, manifested by chills, vomiting a rise in temperature, a rapid fall in blood pressure, and irregularity of the pulse. More severe reactions are marked by cyanosis, dyspnea, and diarrhea, and occasionally collapse and death. Usually however, the patient recovers spontaneously without special treatment. These reactions have been variously ascribed to impurities in and faulty sterilization of the solution, foreign bodies and deposits on the apparatus, a too rapid introduction improper temperature of the solution, and faulty pH content (32, 116)

Co Tui and his associates (23) are of the opinion that the responsibility lies in a "pyrogenic substance of a particulate nature, the separate particles being more than 50

millimicrons in size and that the infusion fluid can be freed of this substance if it is passed through a compressed asbestos filter of the Seitz serum, No 3 type Rowntree (94) believes these reactions may be due to water intoxication, as he has observed symptoms resembling those of edema of the brain—notably nausea, vomiting, headache, vertigo, rise in blood pressure, muscular twitching, and unconsciousness—whenever the fluid intake exceeded the output While these untoward reactions sometimes occur, their incidence has been greatly reduced of late, due to the more careful attention directed to the details involved in the administration of the fluid However, they occasionally appear, even after the utmost precautions

Technic of Intravenous Infusion The apparatus used for intravenous administration comprises the following parts (1) A container for the solution, a few of those in common use being shown in Figure 185 Some provision is made for the maintenance of the fluid at a constant temperature of between 120 and 130°F , so that the solution may be delivered into the vein at approximately 100°F . A higher or lower temperature is said to result in a liberation of fibrin A convenient method has been suggested by Standard (98) who runs the tubing along the wrist and forearm to the cubital vein and bandages it next to the skin (fig 186c) The body heat plus the original warmth of the solution is sufficient to maintain the temperature The ill effects of possible cooling have probably been overemphasized, since the infused liquid meets with so large a blood volume that this danger must necessarily be minimal The container must be sterilized and washed in distilled water before it is used (2) A rubber tube 4 to 6 feet in length and of a diameter of a #10 catheter, to be affixed to the container The tubing should be made of pure gum with a glass section somewhere along its length so that air bubbles may be seen and stopped before they reach the circulation, and equipped with a terminal tip that will fit into a cannula or needle The rubber tube is sterilized by being boiled in a strong solution of soda, rinsed in running water, then reboiled in plain water for 1 hour In order that the talcum and sulphur clinging to its interior may be removed, it should be stretched and twisted before and after boiling and rinsed in distilled water, after which it should be sterilized in an autoclave (3) A cannula of metal or glass, or a #15 to #17 gauge blood chemistry needle, or a #18 gauge McNealy needle, to be introduced into the vein

All solutions must be freshly made, the water used triply distilled, and only the purest chemicals employed They should be filtered 5 or 6 times, so that any particle of dust or cotton fiber may be removed At the Mount Sinai Hospital in New York, according to Lewisohn (66), with the establishment of a special department for the proper preparation of instruments and solutions for intravenous therapy, posttransfusion chills were reduced from 12 per cent in 1930 to 1 2 per cent in the period from October, 1931 to October, 1932 The hydrogen ion of the solution must be of a fixed concentration Williams and Swett (116) believe there is a definite relationship between the hydrogen ion concentration of the injected fluid and its tendency to produce a reaction They have shown "that a boiling for 20 minutes changes the pH of a 10 per cent glucose solution from 6 20 to 5 17 and that if the solution is allowed to stand in a container for twenty-four hours its pH changes from 6 60 to 5 15 " The possibility of reactions arising from pH variations can be avoided by the use of fresh solutions or by the addition of a buffer agent

The vein usually chosen for intravenous administration of solutions is the median basilic, and that on the left side is preferred, since it is larger and more constant in

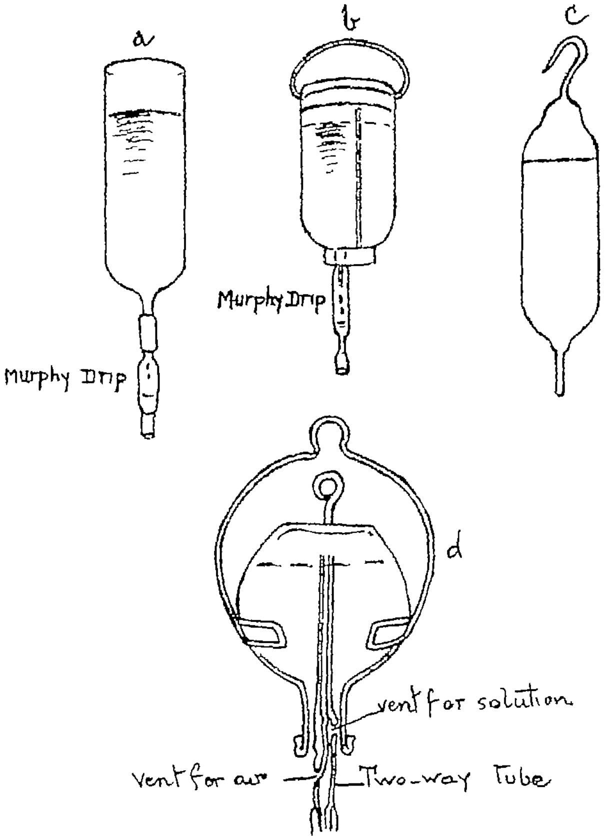

FIG 185 Various types of infusion containers *a* air vent at open end of container *b* similar to *a*, except that air vent is obtained through extra tube in container *c*, sealed container in which air vent is obtained by breaking upper end of tube. *d*, container in which air vent is incorporated in tube. (Standard)

position than that on the right As the brachial artery lies immediately beneath the vein, being separated from it only by the bicipital fascia, care should be taken not to injure the artery, otherwise, an arteriovenous aneurysm may result. Another vein that may be employed to advantage is the anterior saphenous at the point where it passes in front of the internal malleolus In the case of infants, where it is sometimes difficult to locate a vein, the superior longitudinal sinus may be employed, the needle being introduced through the anterior fontanel Gallie and Harris (39) suggest that the vein chosen be as small as will accommodate the needle, in order to permit of as rapid a flow as possible and thus prevent thrombosis

If the median basilic vein is to be utilized, the patient's arm is bandaged to a well-padded arm board, the skin of the anterior surface of the elbow is aseptically prepared

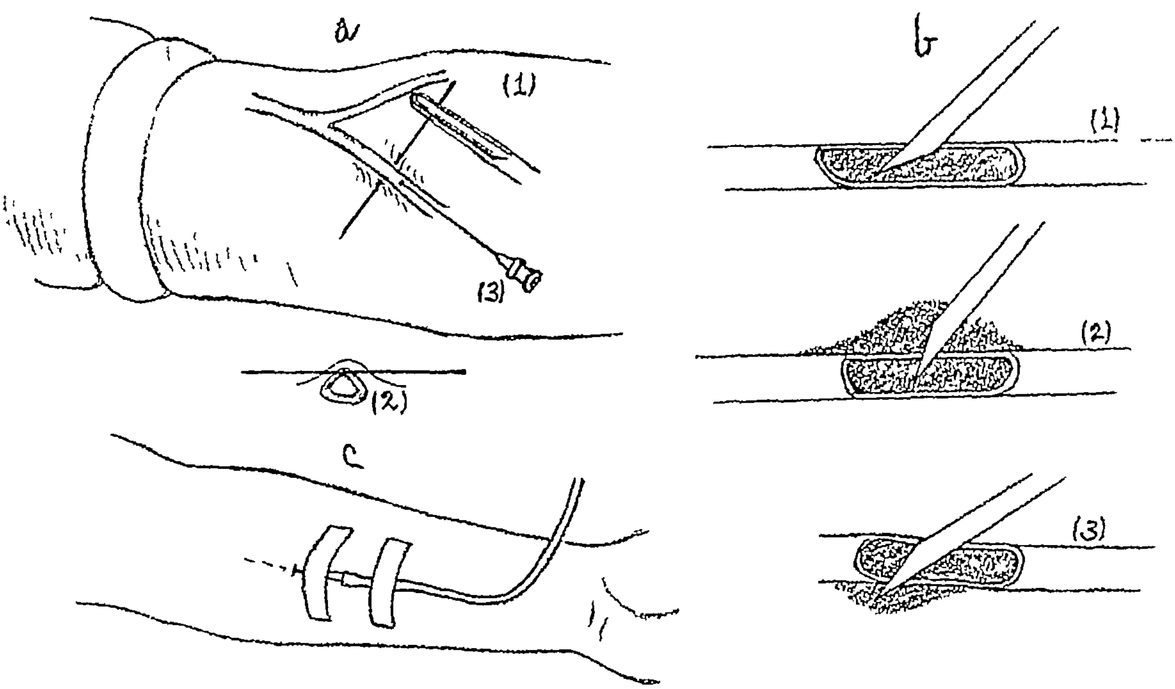

Fig 186 Intravenous infusion *a*, transfixion of vein *1*, sewing needle passed through skin and wall of vein, and lifted to immobilize and render vein prominent *2*, sectional view of transfixed vein *3*, infusion needle introduced (Watson) *b*, introduction of needle into vein *1*, correct position of bevel *2–3*, incorrect position of bevel, resulting in hematomata formation or perforation of posterior wall (Lundy) *c*, needle connected with infusion apparatus and anchored to arm with two strips of adhesive tape

the part is draped, and the site of puncture anesthetized with 1 or 2 drops of procain solution (p 408) The vein may be made to stand out prominently by wrapping a pneumatic cuff around the arm and inflating the cuff to a point between systolic and diastolic pressure, having the patient clench his fist, milking the vein from below upward, or, as suggested by Lewisohn, by tapping the vein briskly or placing the arm in warm water An ingenious method of isolating the vein has been described by Watson After the tourniquet has been applied, a round sewing needle is introduced into the skin at right angles to the line of the vein, passed through the vein, and the point brought out through the skin of the opposite side When the needle is lifted, the vein thus transfixed is immobilized and rendered prominent (fig 186a)

The solution may be introduced into the vein by means of a needle (fig 186) or it may be injected through a cannula If the former method is preferred, the vein is

immobilized with the left thumb and index finger and the needle—attached to a syringe half full of normal salt solution and its bevel pointing downward—is thrust through the skin into the vein. Lundy (70) states "The needle chosen must be one which certainly will enter the lumen of the vein If the needle is estimated to be almost the size of the lumen, then the bevel should be turned down as has been illustrated (fig 186b) If the needle is smaller, it makes no difference which way the bevel is introduced through the skin or venous wall." In order to make certain that the needle is actually in the vein, a small amount of blood is withdrawn before the introduction of the solution The tourniquet is then gently released, the syringe is removed, and, after all air has been expressed from the infusion apparatus, the needle is connected with the tip of the rubber tube, and thus a communication es-

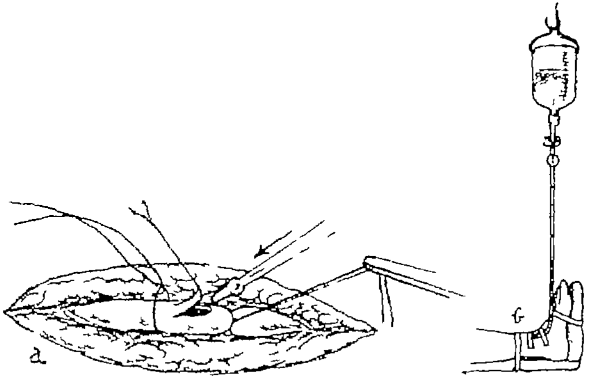

FIG. 187 Intravenous infusion through cannula. *a*, vein exposed Two catgut ligatures passed around it. Distal ligature tied to occlude vessel, and ends left long for traction. V-shaped snip made in vein, and flap reflected. Cannula introduced into aperture and held in place by tying proximal ligature. *b* cannula connected to infusion apparatus.

tablished with the source of supply The needle is anchored to the arm by means of 2 strips of adhesive tape, one strip being placed across the needle and the other across the tube, after which the arm is splinted.

If the vein cannot be demonstrated or is collapsed, or if a more rapid introduction is desired than can be obtained through a needle, the vein is cut down upon and a cannula inserted. An oblique incision is made in the skin across the line of the vein, a small hemostat is introduced into the wound, and its jaws opened to expose the vein, which is cleared for the space of 1 inch (fig 187a) With an aneurysm needle 2 catgut ligatures are passed beneath the vein The distal ligature is tied in order to occlude the vessel, and the ends are left long to be used for traction while the vein is being opened. With a pair of sharp-pointed scissors a small V-shaped snip is made across the anterior wall of the vein, forming a miniature flap with its apex downward. The

cannula is then introduced into the aperture and secured in the vein by tightening the proximal ligature over it The pneumatic cuff is now deflated, the cannula connected with the apparatus, and the fluid allowed to flow into the vein (fig 187b) As said before, in order to exclude air the fluid should be already flowing when the connection is made A constant stream through the cannula should be maintained throughout the course of the injection Should the stream become blocked, the nipple is detached and the clot sucked out with a syringe If during the infusion the patient becomes dyspnoeic and cyanosed or complains of syncope, the infusion is interrupted and artificial respiration instituted When a sufficient quantity of fluid has been introduced, the cannula is removed and the vein occluded by tying the proximal ligature. Finally, the skin wound in the arm is closed with 1 or 2 silk sutures, and a dressing is applied

Rate of Infusion. Intravenous solutions may be delivered rapidly, or given slowly by means of a continuous intravenous drip, the rate of flow depending upon the therapeutic indication For instance, in the case of hemorrhage and shock the flow should be rapid enough to bring about an approximately normal blood pressure in as short a time as possible Four hundred to 500 cc are administered in the course of a few minutes, since the danger of overloading the heart is negligible until the blood pressure approximates the normal When it has been raised to within 10 to 15 degrees of normal, the rate is reduced to 150 to 200 cc per hour and continued at this rate until the clinical condition is satisfactory If necessary, the operation may be performed while the fluid is being introduced, the need for increasing or decreasing the quantity being regulated by the blood pressure

The slow intravenous or drip method of introducing parenteral fluids (venoclysis) makes possible the introduction of large quantities of fluid with comparative safety, as it does away with the danger of overtaxing the heart and circulation It also obviates the risk of breaking down the compensatory mechanism which controls the reaction, osmotic tension, and viscosity of the blood, and reduces the hazards of post-infusion reaction Hirshfeld and Hyman (52) studied the effects of velocity of intravenous injection and came to the conclusion that the rapidity of introduction of the fluid into the blood stream, rather than the nature of the substance, was responsible for a syndrome characterized by a rapid fall in blood pressure, irregular respirations, and a diminished coagulability of the blood, which they termed "speed shock." The A. M A Council on Pharmacy and Chemistry report in the journal of the Association 1927 to 1929 as follows "Intravenous injections should always be given slowly Rapid administration introduces several hazards (a) the danger of overwhelming the heart and circulation with too great a volume of fluids, (b) the risk of breaking down such compensatory mechanisms as those which maintain the reaction of the blood, its osmotic tension, its viscosity and the like within the very narrow limits of normality, and (c) the likelihood, especially in the case of active drugs, of having them carried to the heart, the central nervous system or other vital structures in dangerous concentration "

Slow intravenous infusion is especially beneficial in cases of severe dehydration, shock, hemorrhage, and toxemia, and in conditions requiring large quantities of fluid over a period of several days Detracting somewhat from the advantages of this method are the relatively greater dangers of clotting within the needle, infection, thrombosis, and pulmonary edema, although with care these risks can be for the most part averted

Hirshfeld and Hyman (52) describe the drip method of infusion as follows "The apparatus required includes

1 A stand for the infusion reservoir
2 A 250 cc. graduated flask of the arsphenamine type
3 Two pieces of rubber tubing respectively 30 cm. and 150 cm. long
4 A connecting tip for needle or cannula
5 A rectal drip
6 A Hoffman clamp
7 An artery clamp
8. A 2 cc. and a 5 cc. syringe
9 Intravenous needles
10 Intravenous needle-cannulas.

The entire set is thoroughly cleansed and sterilized. The two pieces of rubber tubing are connected by the rectal drip and the free end of the shorter piece is attached to the reservoir Between the reservoir and the drip is placed the Hoffman clamp The reservoir and tubing are filled with the solution, the clamp is loosened, and all air bubbles are expelled " The cannula or needle is introduced into the vein in the usual manner The connecting tip is then attached to the cannula or needle and "the flow is immediately started lest clotting occur in the needle or the adjacent segment of the vein. The arm is immobilized by wrapping it in a large pillow fastened together with safety pins. All these technical details arranged, the rate of flow is adjusted by the Hoffman clamp so that not more than 50 nor less than 20 and preferably from 30 to 35 drops fall in each minute. The rate of flow is not regulated until all other variables are controlled. Electrical pads or hot water bottles are arranged over the pillow and around the terminal third of the tubing It is not necessary to heat the supply in the reservoir

Thus assembled we have used the intravenous drip for as long as eleven days without interruption, and with only occasional adjustments of the Hoffman clamp At a rate of 2 or 3 cc. per minute, from 3 000 to 4,000 cc. of fluid is introduced daily If a 5 per cent solution of dextrose is employed from 150 to 200 grams of the sugar will be administered and will supply from 600 to 800 calories in twenty four hours.

"In the event of any interference with the rate of flow of the infusion, the rubber tubing is examined to make sure that no kink has occurred To ascertain whether the needle has slipped from or torn through the vein, the pillow and dressings are removed. In either case the tissues will be infiltrated. If by any chance the needle has become plugged the connecting tip is removed, and occasionally if the obturator is reintroduced the clot may be dislodged and the infusion resumed."

Technic of Blood Transfusion

A. Whole Blood. Whole blood may be transfused directly by connecting the radial artery of the donor with the vein of the recipient by means of a cannula, but this method has become obsolete because of the difficult technic involved, the inability of measuring the quantity of blood, and the danger of infecting the donor A simpler method and one which overcomes these objectionable features consists of the introduction of the blood into the vein of the patient after its withdrawal from the donor by means of a needle and syringe or by the use of a paraffin-lined container, such as

that of Kimpton-Brown or Percy The success of this procedure depends on the prevention of clotting, rapid transference of the blood, and adequate assistance The technic in brief is as follows. The donor and recipient are placed on operating tables between which is set a table sufficiently long to allow the outstretched arms to rest upon it (fig 188) After the arms of both donor and recipient have been aseptically prepared, a tourniquet is applied to the recipient's arm, and a small quantity of procain solution is infiltrated into the tissues over the vein The vein is isolated through a small incision and elevated by means of traction exerted on a double piece

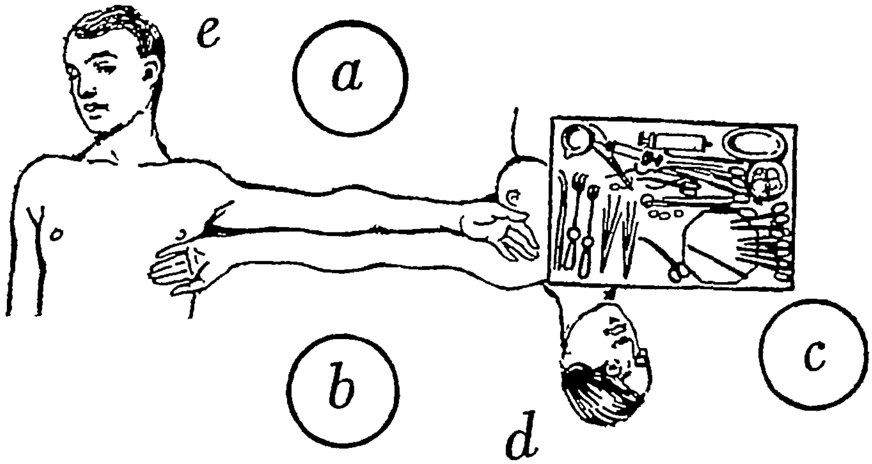

Fig 188 Whole blood transfusion *a*, assistant *b*, surgeon *c*, instruments *d*, donor *e*, recipient (Kirschner's Surgery)

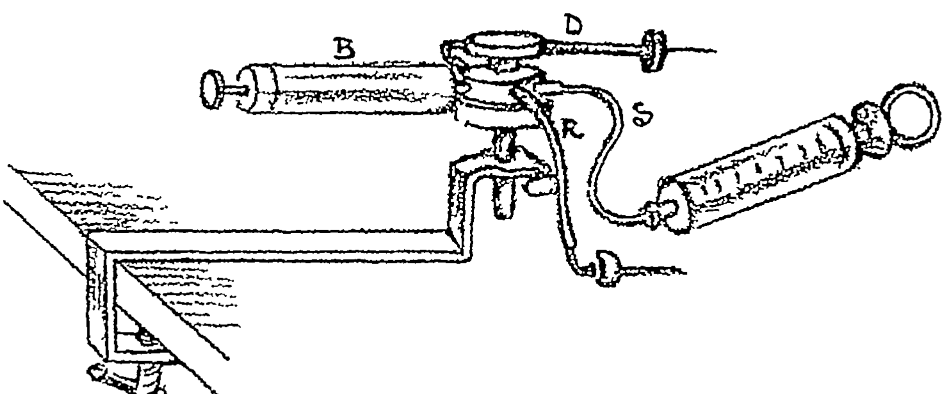

Fig 189 Unger's apparatus for syringe transfusion *D*, recipient's cannula, *R*, donor's cannula, *B*, Record syringe for aspiration and injection of blood, *S*, saline syringe "At any one moment, saline solution is forced through that cannula through which blood is not passing This automatic shunting is accomplished by the stopcock "

of #0 plain catgut introduced beneath it, and with a knife an opening is made into it By the exertion of a little more traction on the ligature the vein is now closed and not reopened until the Kimpton tube is ready for introduction A large needle is then inserted into the donor's vein and connected with the paraffin-lined tube As soon as sufficient blood has been drawn into this tube, it is removed and introduced into the recipient's vein While the surgeon is injecting the blood, the assistant fills the second tube. This process is repeated until the required quantity of blood has been administered, at which time the needle is removed from the donor and a pressure dressing applied The skin of the recipient's arm is closed in the usual manner

Unger (108) describes a convenient method of transfusing unmodified blood "The required materials are (fig 189)

An Unger Transfusion instrument
Unger transfusion needles (donor patient and infant) with adaptors
One 20 cc. Record and one 20 cc. Luer syringe
One No 17F soft rubber catheter
Two rubber tourniquets
One small basin for normal saline.

Technic All the instruments are sterilized in the usual fashion. Donor and patient are placed on stretchers lying parallel to one another but about a foot and one-half apart. Between the stretchers is placed a board on which rests the patient's and donor's arms. It is advisable to use either right or left arms of both donor and patient. This makes it necessary for them to lie in opposite directions. The arms chosen are painted from wrist to axilla with tincture of iodine and draped with sterile sheets. The operator standing next to the donor's head attaches the stand of the instrument to the board lying between the stretchers. An assistant stands directly opposite the operator On the stand of the instrument is mounted the stopcock composed of an outer rim with four outlets and an inner stopper The mechanical principle involved is the establishment of two channels by which a Record syringe is automatically connected alternately with a vein of the donor and then with one of the recipient. At the same time that the Record syringe is connected with the donor for the aspiration of blood, a syringe with saline solution is connected with the recipient and vice versa.

"A No 17 French soft rubber catheter is now cut into three pieces, two four inches in length and one two inches. The four inch pieces are attached to the outlets nearer the donor's and patient s arms and are used to connect their needles to the instrument. The two-inch piece is attached to the intermediate outlet and is used for the injection of saline. The fourth outlet is for a 20 cc Record syringe by which the blood is transfused.

"A tourniquet should be applied first to the donor's arm. It is important that it be adjusted with such tension that it just fails to obliterate the pulse. Next apply a tourniquet to the patient's arm. The patient s needle, pointed toward the axilla is plunged through the skin into the patient's vein as if for taking blood for a Wassermann test. No incision or even skin nick should be made. The trocar of the needle is removed and then the tourniquet. After the stopcock of the transfusion instrument has been turned toward the donor, saline is forced through it thereby expelling all air By means of the four-inch length of tubing the patient s needle is now connected with the transfusion instrument.

"The donor's needle, without any skin nick or incision being made, is inserted into the donor's vein but here it is pointed toward the wrist. This is in a direction opposite to that used when ordinarily making venepunctures, and insures a much freer flow of blood. By means of the second four inch piece of tubing this needle is now connected with the instrument. The donor's tourniquet is at all times left in place. Blood having now run out of the fourth or blood outlet forcing air ahead of it, a 20 cc. Record syringe is inserted and blood is aspirated. When it is filled the stopcock is turned as far as possible toward the patient and blood is injected. The stopcock is now

turned back to the donor, a second syringeful is obtained and then emptied as previously This is continued until the desired amount has been transfused About eight seconds are required to fill and empty a syringe The speed, however, can be varied at will and if indicated the time taken to transfer blood can be lengthened by adding periods during which the transfusion is completely interrupted During these periods the instrument and both syringes are kept filled with normal saline solution While the operator transfers the blood the assistant slowly but continuously forces saline out of his syringe He does nothing else

"Turning the central stopper not only shunts the blood from the donor to the patient but also automatically directs saline through that needle which at that moment is not being used for aspiration or injection of blood.

"It is this immediate and continuous flushing with normal saline that insures freedom from clotting In addition, from an ether can into which one very fine hole has been made, a nurse sprays ether onto the blood syringe The ether evaporates rapidly, chills the blood in contact with the glass wall and insures freedom from the very earliest coagulative changes It also keeps the metal piston contracted so that one syringe can be used regardless of the size of the transfusion When the desired amount of blood has been given, the needles are withdrawn and the arms are bandaged."

B **Citrated Blood:**

(1) *Collection of Blood from Donor* The blood is procured in the following manner (fig. 186). The donor lies on a table with his shoulder projecting somewhat beyond the edge The arm is held dependent and rotated outward. The vein is made prominent by means of a blood pressure cuff, inflated from 75 to 85 mm of mercury, the vein being thereby compressed without interference with the radial pulse The skin is sterilized in the usual manner and the hand and lower part of the forearm are draped with sterile towels A wheal is raised over the proposed site and a previously lubricated #14 gauge needle introduced into the vein caudalad A large-mouthed aluminum or glass flask containing citrate (10 cc of a 2.5 per cent solution of citrate for every 100 cc of blood) is placed beneath the needle and the blood collected The blood is stirred continuously to insure of adequate mixing and gently to avoid damage to the red cells When the required amount has been obtained, the pressure of the cuff is relaxed, the needle removed, and the site of puncture dressed The donor is served a light lunch and ordered to rest quietly for half an hour before leaving the hospital The average quantity of blood which can safely be furnished by a male donor is 800 cc and by a female 650 cc

(2) *Transfer to Recipient* The blood is introduced into the recipient in the manner described on page 000, either the rapid or the slow method of introduction being used, depending upon the indication

Hedenius (50) suggests the intravenous injection into the donor of 1 mg per kilogram of body weight of a sterile 5 per cent solution of heparin in place of the addition of citrate solution to the drawn blood, and claims. "It has all the advantages of the citrate methods but none of the disadvantages, such as a possible excess of anticoagulant when the expected amount of blood is not obtained The transfusion can be performed with any equipment available and the technique should prove of value particularly in performing transfusions away from hospitals"

Bates (4) describes a simple and practical plan for the transfusion of citrated blood

(fig 190) which is used at the Passavant Memorial Hospital in Chicago "A liter Florence flask is fitted with a two-hole rubber stopper through which a long U tube reaching to the bottom conducts the donor's blood when the flask is upright but acts as an air vent when the flask is inverted to discharge the blood The other hole in the stopper admits a short glass Y tube, one arm of which connects to a detachable Potain aspirator providing suction when drawing the blood. The other arm of the Y (conducting blood to the recipient after the bottle is inverted) is equipped with a drip view and 3 feet of rubber tubing terminating in a small side arm intravenous syringe. Pinch clamps on each side of the Y, a gauze filter on coiled wire in the neck of the flask, and glass covers over the needles complete the apparatus.

'A nurse in sterile gown and gloves assembles the previously autoclaved parts into a unit, which is then laid aside ready for future use. The assembly includes placing

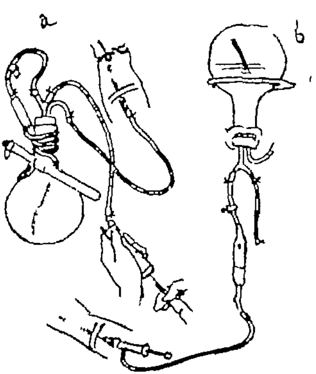

FIG 190. Bates apparatus for transfusion of citrated blood. For details see text.

60 cc. of 2.5 per cent sodium citrate solution in the flask and inserting the filter and the stopper with the attached tubing Finally the No 16 donor's needle and the No. 18 recipient's needle are fitted with glass covers and the unit is then placed upright in a sterile bag

"The preparation of either donor or recipient with iodine and alcohol and tourniquet is as simple as drawing blood for a *Wassermann test*. Strong suction should not be used in drawing the blood the flask should be agitated gently and when the desired amount of blood is drawn (up to 600 cc.) the donor's needle and tubing are immediately detached and washed. The rate of flow into the recipient may be increased by forcing air into the U tube with the Potain aspirator but this procedure is rarely necessary Hot water bottles placed about the flask and against the exit tubing insure warm blood for the recipient."

MANAGEMENT OF ACID BASE IMBALANCE

Acidosis

Acidosis is frequently preventable, and its serious consequences can often be forestalled by careful management Since it is not a disease but a symptom complex, its control is directed toward the removal of the causal agent In patients suffering from diabetes an impending acidosis may be prevented by regulation of the diet and administration of insulin (p 478), in chronic interstitial nephritis an abundance of fluid and the judicious use of diuretics is indicated to promote the excretion of retained phosphates and other toxic products, in cases of dehydration restoration of the normal water balance by the forcing of fluids will do much to prevent acidosis

The active treatment is essentially symptomatic The patient should be kept quiet and warm Fluid is given in the form of physiologic normal salt solution The salt tends to restore the electrolytic pattern and the osmotic equilibrium, and the water dilutes the toxic products and aids in their elimination (p 349) Glucose is administered to counteract the ketosis present either as a causal or a concomitant factor If oral administration is impracticable, the glucose may be given intravenously as a 10 per cent solution in combination with the saline, in the proportion of 10 cc per pound of body weight The glucose solution, by supplying a readily oxidizable form of carbohydrate, not only furnishes caloric energy, but also restores the depleted liver glycogen, it likewise acts as a diuretic, assisting in the excretion of phosphate and toxic by-products, finally, it facilitates complete reduction of the fats and thus prevents the formation of additional ketone bodies When indicated, insulin may be added to the solution up to the proportion of 1 unit to each 2 grams of glucose administered

The deficiency of the base can ordinarily be compensated for by the use of a sufficient quantity of normal sodium chlorid solution, but occasionally alkalies, such as sodium bicarbonate, are indicated Although the use of alkalies is based on sound physiologic principles, they must be employed with discrimination, lest they overcorrect the condition and produce a state of alkalosis Especially is this true in children, who are subject to vomiting which leaves them in a state of chlorid de[illegible]
Under such circumstances a very small amount of sodium b[illegible]
alkalosis Therefore, when the administration of an alkali [illegible]
dioxid-combining power of the blood should always be es[illegible]
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of body weight It may be administered or[illegible] of 1 t[illegible]
glucose-sweetened water, repeated every 2 [illegible] the r[illegible]
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combined with 500 cc of a solution of 10 p[illegible] trav[illegible]
per kilogram of body weight of a 5 per ce[illegible] bica[illegible]
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Hartman and his associates (48, 49) advc[illegible] lac[illegible]
that it is completely metabolized and liberate[illegible] than
bicarbonate It is administered hypodermica[illegible] a 1
solution in the proportion of 10 to 20 cc per ki[illegible] [illegible]ily

Alkalosis

In the treatment of alkalosis the aim is to combat dehydration and starvation, promote renal secretion, aid elimination through the bowels, and replace the lost chlorids. These aims are met by the intravenous administration of dextrose in normal salt solution (p 350) When insulin is necessary to balance the glucose solution, only one-half the carbohydrate given intravenously should be so neutralized In the absence of dehydration the lost salt is best supplied in the form of a hypertonic saline solution up to 2 per cent. The chlorids may also be furnished in the form of an enema containing 100 cc. of a 2 per cent solution of ammonium chlorid administered every 2 hours. The ammonium chlorid is absorbed and converted into urea and chlorin, the latter serving to replace the depleted acid radical Acid-forming salts may be administered orally in the form of ammonium chlorid or ammonium nitrate in 1-gram (15-grain) doses at 4- to 6-hour intervals.

Muscular spasms and convulsions are treated symptomatically by the use of anti spasmodics. They often respond to the intravenous administration of 5 cc. of a 10 per cent solution of calcium chlorid

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Hartman and his associates (48, 49) advocate the use of sodium lactate, claiming that it is completely metabolized and liberates sodium more rapidly than does sodium bicarbonate It is administered hypodermically or intravenously as a 1 8 per cent solution in the proportion of 10 to 20 cc per kilogram of body weight daily

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CHAPTER VI

SHOCK

The principal factors responsible for the high surgical mortality of the past were infection and shock. With the introduction of asepsis infection was largely controlled, but unfortunately the problem of shock still defies solution in spite of an enormous amount of experimental and clinical work Although the incidence and severity of shock have been greatly reduced in recent years by attention to physiologic principles, better hemostasis, more skilful anesthesia, and atraumatic surgery, it is nevertheless still responsible for many disasters

The word "shock" in its surgical sense was coined by Latta in 1795, and despite the unscientific vagueness of the expression, it has since become established in the literature through long usage and is retained mainly because there is no other satisfactory term to replace it The term is used here to indicate a clinical manifestation consequent upon physical or psychic injury and characterized (1) by a decrease in blood pressure resulting from a disproportion between the blood volume and the vascular bed, due either to (a) an *absolute diminution*, as in the case of a loss of whole blood from hemorrhage or of a loss of plasma from transudation through abnormally permeable capillaries, or to (b) a *relative diminution* due to dilatation of the capillary bed, and (2) by acute circulatory collapse, lowered metabolism, increased concentration of the blood, and anoxemia

Etiology

Many factors, either alone or in combination, have a bearing on the production of shock, chief among these being age, sex, exhaustion, pain, exposure to cold and heat, loss of blood, trauma, adverse nervous and mental stimuli, starvation, dehydration, anemia, and infection Persons of advanced years do not endure shock well, but as will be seen later (p 455), it is not the chronologic age of the patient but the "age" of his circulatory apparatus that determines his reaction to the condition While shock is common in infants and young children due to the instability of their nervous systems, yet during the first 3 weeks of life they seem to be less predisposed, as demonstrated in the case of infants undergoing operations for cleft lip or cleft palate Before puberty there is little difference in susceptibility between the sexes Subsequently, the female, except during the child-bearing period, is more prone and remains so until after the menopause, when she becomes a better surgical risk than the male There is clinical evidence to prove that the time of day has an influence on the production of shock. During the early hours the vital processes are most active and the body reserve is at its maximum, but between one and two o'clock in the morning resistance is at its lowest This is borne out by the fact that after prolonged illness more deaths occur at this time than at any other Adverse psychic stimuli unquestionably favor the production of shock, but it is difficult to assess the extent of their influence, since they are unavoidable concomitants of all surgical operations Nervous patients are noto-

nously bad risks, and it not infrequently happens that in them pain and excitement alone are sufficient to bring about the syndrome. Even the apprehension associated with the administration of a local anesthetic may precipitate a fall in blood pressure. This nervous predisposition probably explains the greater incidence of shock among the more highly cultured races.

Classification

As far back as 1870 it was customary to classify shock as "primary" or "secondary," according to the interval of time elapsing between the receipt of the injury and the onset of the syndrome but as questions arose regarding the pathogenesis of secondary shock, this classification was abandoned. During the World War, however, with the introduction of the theory of traumatic toxemia as a possible cause, the terms "primary" and "secondary" shock once more made their appearance. *Primary shock* develops immediately after the infliction of psychic or physical injury and is probably of neurogenic origin, due to a reflex vagal stimulation with a dilatation of the splanchnic vessels. It is characterized by a fall in blood pressure unaccompanied by any decrease in blood volume. The condition is usually temporary, the patient recovering promptly even in the absence of treatment. If the low blood pressure persists for any length of time, however it may lead to secondary shock. *Secondary shock* (*traumatic shock*) appears 1 to several hours following trauma and unlike the primary form, is associated with a decided reduction in blood volume accompanying the fall in blood pressure.

Pathogenesis

Much thoughtful investigation has been directed toward the solution of the pathogenesis of shock. While many theories have been advanced, they are for the most part contradictory and cannot be integrated to adequately explain the mechanism. The difficulty lies in the fact that the syndrome may be initiated by any one of a variety of factors, each having a different physiologic basis. It is not the purpose here to enter into an academic discussion of the innumerable opinions offered, nevertheless, it may be of advantage to review briefly those theories which have contributed some item of practical utility for the prevention and treatment of shock or have thrown some light on its mechanism.

Hematogenic Shock

Hematogenic shock, according to Blalock (12) is a type in which there is 'an initial decrease in blood volume which is followed by vasoconstriction and a decrease in the cardiac output and subsequently there is a decline in the blood pressure.' The fall in blood pressure is due to the escape of vascular elements through the damaged capillary walls into the tissue spaces. Early this extravasation is limited to plasma. The extravasated plasma proteins, by their osmotic action, draw an additional amount of fluid from the circulation thus increasing the disproportion between the blood volume and the vascular bed. As a consequence of the fluid loss the cellular elements in the blood vessels tend to become more concentrated, manifested clinically by an abnormally high specific gravity and an increase in the number of red and white cells in the

capillary vessels This viscosity of the blood hastens the tendency to stagnation and further damages the endothelial cells, thereby accentuating the extravasation. Thus a vicious cycle is set up During this stage, therefore, the best means to raise the blood pressure is to replace the lost volume with blood plasma Obviously, a transfusion of whole blood under such circumstances would be contraindicated, inasmuch as the cellular elements are already in a state of concentration In hemorrhage, on the other hand, the problem is somewhat different Here the blood pressure is maintained for a time by the contraction of the circulatory bed upon the diminished blood volume, and by the action of the plasma proteins which draw fluid from the tissues into the capillaries When approximately $\frac{1}{2}$ of the blood volume has been lost, the compensatory mechanism fails, manifested by vasodilatation and a sudden fall in blood pressure This condition, because of the loss of cellular elements, will respond to whole blood transfusion At this stage the two conditions can be differentiated by laboratory findings In hemorrhage the blood is diluted from the absorption of fluid from the extravascular bed, whereas in shock it is in a state of concentration Such a differentiation is of great importance since the indications for the treatment may be entirely dissimilar For instance, in the case of severe hemorrhage immediate operation to control the bleeding vessel is imperative, whereas in shock operative intervention may prove fatal

In the later stages of shock there is in addition to extravasation of serum an escape of cellular elements as well, and at this stage shock and hemorrhage are indistinguishable Thus Cannon states "Shock is hemorrhage and hemorrhage is shock"

Blalock (11) declares that "hemorrhage alone may present the same findings as shock due to trauma if the blood pressure remains at a low level for a considerable time preceding death The reason that these findings are not observed in patients who succumb to uncomplicated hemorrhage is that death follows rather rapidly in most instances without a prolonged period of low blood pressure" In the case of fully developed shock, therefore, blood transfusion, as in hemorrhage, is the most valuable expedient to increase the pressure and supply oxygen-carrying cells

Vasogenic Shock

Vasogenic shock is initiated by vasotropic substances elaborated at the site of injury and absorbed into the circulation, acting directly upon the blood vessels to depress their vasomotor tone and cause a fall in blood pressure

It is well known that the capillaries, when dilated, are capable of accommodating a great volume of blood, and that only a small part of the capillary bed functions at any one moment as a channel for the blood Due to the loss of vascular tone resulting from vasogenic shock, the blood stagnates in the capillary network, instead of returning to the heart by way of the veins To use Cannon's words "A considerable part of the blood passes out of currency" This stagnation in time causes the endothelial cells of the finer capillaries to become damaged to such an extent as to increase their permeability and permit of an escape of their contents (fig 191)

The causative agents of vasogenic shock have been thought to be toxic substances (28) liberated in traumatized tissue, especially in the case of injuries involving the crushing of muscles To explain primary shock on this basis, the proponents of the theory assume that immediately after the injury a toxin in the form of a non-autolyzed pro-

tein passes into the circulation from the contused tissue, and to account for secondary shock, they assume that the traumatized proteins are broken up into amino-acids which on decarboxylization are transformed into toxic amins, such as histamin and other histaminlike bodies. This hypothesis offers the best explanation of shock associated with burns (p 308)

At the present time, however, there is no evidence sufficiently convincing to indicate that shock can be induced by a depressor toxin derived from traumatized tissue. O'Shaughnessy and Slome (78) conclude that neither histamin nor any other depressor substance manufactured in the traumatized area plays any part in the initiation of

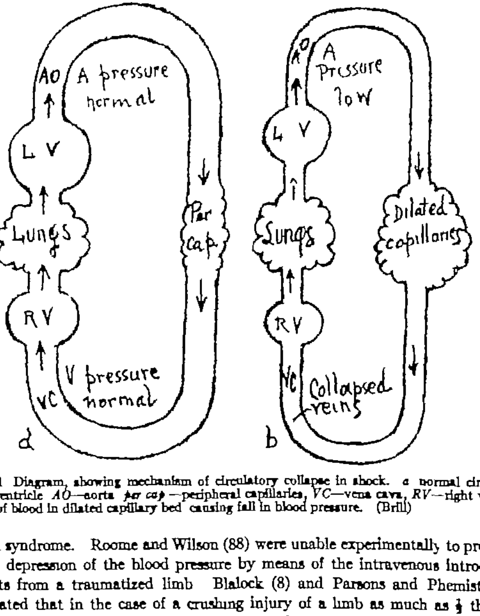

FIG 191 Diagram, showing mechanism of circulatory collapse in shock. *a* normal circulation. *LV*—left ventricle *AO*—aorta *per cap*—peripheral capillaries, *VC*—vena cava, *RV*—right ventricle. *b* pooling of blood in dilated capillary bed causing fall in blood pressure. (Brill)

the shock syndrome. Roome and Wilson (88) were unable experimentally to produce a sustained depression of the blood pressure by means of the intravenous introduction of extracts from a traumatized limb Blalock (8) and Parsons and Phemister (80) demonstrated that in the case of a crushing injury of a limb as much as ½ the total volume of blood may accumulate in the tissues of the part, and it is to this, rather than to the absorption of toxins, that they attribute the decline in blood pressure following trauma. Holt (45) summarizes the objections to the toxemic theory as follows

(1) That no observer has satisfactorily demonstrated the presence of any depressor substance in the venous blood from a traumatized area. (2) That the circulatory changes of traumatic shock differ considerably from those produced by the injection

of histamine or other depressor substances obtained from tissue extracts (3) That the comparative weighings of the normal and traumatized limbs, as practised by Cannon and Bayliss, failed to give a true picture of the extent of the extravasation and hemorrhage into the damaged area"

While the toxemic theory has thus been seriously challenged, it has served to create a new concept of the nature of shock and has helped somewhat to elucidate its mechanism Moreover, in view of the fact that the incidence and severity of shock has decreased since the introduction of an atraumatic technic, the possibility of absorption of toxic substances from injured tissues cannot be ruled out In this connection Dale (27) (1933) writes, "We should be unwise on the ground of negative results of experiments to discount altogether the possibility that rough handling and exposure of tissues might liberate toxic substances into the circulation and produce shock"

Neurogenic Shock

Attempts have been made to explain shock on a neurogenic basis It has been assumed that adverse stimuli, acting directly or reflexly through the autonomic fibers of the vagus, cause a diminution of vasoconstrictor tone resulting in vascular dilatation and a consequent fall in blood pressure The theory is founded on the experiment of Goltz (38), who demonstrated that a blow on the exposed mesentery of a frog caused a reflex inhibition of the heart and a dilatation of the splanchnic vessels, followed by a gravity accumulation of blood in the dilated splanchnics Blalock (8) accepts this mechanism as the explanation for primary shock

Crile (24), the principal proponent of the neurogenic theory, developed his idea of "anoci-association" on the assumption that shock is caused by a constant bombardment of the brain cells by nocuous afferent stimuli, either psychic, traumatic, toxic, or thermic, which results in exhaustion of the vasomotor center In consequence, the blood vessels dilate, the blood pressure falls, and the blood stagnates in the capillaries. The heart, deprived of an adequate volume of blood, is unable to carry on its function of supplying blood to the medullary centers Crile's (25) investigation led him to believe that shock induced definite morphologic changes in the brain cells Forbes and other investigators, however, showed that these changes were not the initiating factors but rather consequent upon the associated changes in the cerebral circulation Dalley found similar changes in the nerve cells in cases of anemia Further doubt was cast upon Crile's theory by Cannon who was able to produce shock in a cat by a traumatization of the hind leg after the spinal cord had been divided above the lumbar plexus and all the nerves supplying the leg had been severed

Although the anoci-association theory of Crile does not adequately explain the mechanism of shock, there is no question but that harmful afferent stimuli in some way contribute to the syndrome The truth of this statement has been borne out clinically by the fact that gentle handling of tissues, deep anesthesia, and nerve block offer protection against shock

Cardiogenic Shock

Shock has also been attributed to cardiac inefficiency, but clinical evidence does not bear out this theory It has been demonstrated that in shock the nervous and

muscular mechanisms of the heart are capable of maintaining the blood pressure at the normal level, provided the organ is supplied with an adequate fluid volume, as is shown by the rise in blood pressure when the lost volume of blood is made up

Other Theories As to the Production of Shock

Another explanation of the cause of shock which for a time engaged considerable attention was *Henderson's* (41) *acapnia theory* According to this hypothesis the fundamental initiating factor in the production of the syndrome is a loss of carbon dioxid from the blood (acapnia) induced by the hyperpnea resulting from stimulation of the afferent nerves at the time of injury The diminished amount of carbon dioxid remaining in the circulation is insufficient to stimulate the vasomotor centers, and leads to a loss of vascular tone, followed by venous stasis, acidosis, and anoxemia. The acapnia theory was further strengthened by the fact that experimental hyperventilation of the lung was found capable of producing shocklike states. Henderson (41) asserts that in such conditions, given an adequate amount of oxygen and sufficient hemoglobin for its transportation, nothing is so effective in restoring the normal state as the inhalation of carbon dioxid. The theory, however, was not sustained by the members of the British Medical Research Committee, who presented convincing proof to show that acapnia was not the cause of shock

The blood likewise has been studied in an effort to determine whether *acidosis* might be the initiating agent in the production of shock, but the investigations of the British Shock Commission demonstrated that the acidosis was the result rather than the cause of the condition. They were unable to produce the syndrome by intravenous injections of varying amounts of acids into animals.

Shock has also been explained on the basis of a *hyper or hypo-activity of the sympathetico-adrenal system.* Freeman (36) believes that the condition is brought on by an overfunctioning of the adrenal glands, and that arterial constriction rather than dilatation causes the syndrome He reports the experimental production of a shock like state after the injection of epinephrin. According to his assertions, the arterial constriction tends to slow up the blood stream and leads to stasis in the capillaries and to escape of the plasma—all of which phenomena combine to cause a fall in blood pressure. Swingle (101), on the other hand, is convinced that shock is caused by a deficiency of adrenal hormones and proposes the use of adrenal cortex to compensate the loss. The adrenal theory however, is poorly supported, and there is not sufficient evidence at the present time to show that either over or understimulation of the glands is the initiating factor

Finally, *mechanical factors* have been suggested as a cause (75) McDonogh (65) believes that shock is due to a precipitation of protein particles of the plasma in the perivascular lymphatics, capillaries, and arterioles of the viscera. Fat embolism has also been advanced as a cause.

Symptoms

The severity of shock can be estimated from the patient's general appearance, the blood pressure, and the character of the pulse. Keith gauged the degree of shock by the systolic pressure and classified the syndrome as follows

Fully Compensated Shock

Patients suffering from fully compensated shock are considered as being in a state of potential shock In this condition the blood volume is not under 80 per cent of the normal, and the blood plasma is between 80 and 90 per cent The systolic pressure remains above 100, and the pulse rate ranges between 90 and 100 per minute The general condition of the patient is good, although he may be pale and complain of weakness If this state of potential shock is not to pass over into actual shock, preventive measures must be instituted at once

Partially Compensated Shock

This represents the state of actual shock The blood volume is between 65 and 70 per cent of normal and the blood plasma between 70 and 80 per cent The range of systolic pressure is between 70 and 80 and the pulse rate between 120 and 140 per minute The patient's general condition is poor, he is cold, pale, and restless, and complains of thirst, but immediately vomits any fluid administered to him Since a blood pressure below 70 is generally considered the lowest possible level at which the vasomotor mechanism can maintain the peripheral circulation, active measures must be taken at once to raise the pressure if a fatal issue is to be forestalled

Uncompensated Shock

In uncompensated shock the patient is in a precarious state The blood volume is below 65 per cent of normal and the blood plasma between 60 and 70 per cent The systolic pressure is below 60 and the pulse rate between 120 and 160 per minute, or perhaps even imperceptible In such cases the blood pressure is inadequate to maintain the peripheral circulation, and if it is not immediately restored, irreparable damage will be done to the vital centers, since they cannot tolerate deprivation of oxygen for more than a few minutes Death will ensue regardless of any form of treatment, unless the condition is relieved at once Cannon (19) has shown experimentally that a deprivation of oxygen will cause the small pyramidal cells of the cortex to succumb after 8 minutes, Purkinje's cells after 20 to 30 minutes, and the cells of the medulla, cord, and sympathetic ganglia within 45 to 60 minutes

Cardinal Features

The face of a patient suffering from shock is cold, clammy, and of a grayish color tending to become cyanotic The pallor is attributable to an overcompensation of the capillaries, and the cyanosis is probably consequent upon the associated acidosis The temperature is subnormal, due to the perspiration and to a decrease in heat production, which may fall as low as 65 per cent of the normal The respiration is shallow and rapid, and the pulse is increased in rate but decreased in tension and volume The patient complains of thirst and may suffer from nausea and vomiting He is restless and anxious, the reflexes respond sluggishly to stimuli, the muscles are toneless, spontaneous movements are diminished, and the sphincters may be relaxed Renal function is compromised, and the urine is scanty and highly acid, due to the circulatory stasis and the diminished blood supply

The pathognomonic features of shock are as follows

(1) **Reduction in Blood Volume.** The blood volume may be reduced in amount to between 50 and 85 per cent of the total, and the plasma to between 60 and 90 per cent of the normal, according to the degree of shock. The effect of this decrease will depend more upon the condition of the circulatory volume than upon the total volume. There are in the body so-called depots situated in the spleen, liver, lung, and skin which act in the capacity of reserves for the blood in its passage from the right to the left sides of the heart. The function of these depots under normal conditions is to supply the extra oxygen demanded by increased physical exertion. In cases of shock these organs are called upon to add to the circulatory blood volume, raise the blood pressure, and increase the hemoglobin content. It is only when these depots fail that alarming symptoms manifest themselves.

(2) **Fall in Blood Pressure.** The blood pressure falls, but the cause underlying this phenomenon is still a matter of dispute Hewlett (42), Dale (27), Cannon (19) Hooker (46), and others believe that it is due mainly to a dilatation of the capillaries and small veins, with a resultant stasis which prevents an adequate volume of blood from returning to the heart. Friedlaender (37) states that the reason for the drop in pressure is the dilatation of the large venous trunks of the splanchnics. This view is corroborated by the fact that experimentally splanchnic dilatation is followed by a fall in blood pressure. Wallace (104) Frazier (34) and Drummond (29) however, when operating on patients suffering from shock, were unable to detect any splanchnic congestion, and Parsons and Phemister (80) found the intestines rather paler than normal Blalock (9), Rost (89) Malcolm (59), Seelig (96), Lyon (54), and Mann (60) claim that the fall in pressure is a phenomenon associated with vasoconstriction as a result of which the amount of blood returned to the heart is inadequate.

(3) **Concentration of Blood** Because of the transudation of plasma through the abnormally permeable capillary walls there follows concentration, increased viscosity, and stagnation of the blood remaining in the capillaries. Cannon (19) has shown that in shock there is a marked difference between the capillary and venous erythrocyte counts, and believes that the severity of the shock can be roughly gauged by the difference in these counts. He found 6 000 000 red blood cells in the capillaries and an approximately normal number in the veins Orr (77) states that a leukocytosis up to 20 000 or more, with a predominance of polymorphonuclear cells, may develop within 1 to 2 hours after the onset of shock and disappear within 48 hours.

(4) **Changes in Blood Chemistry** When the systolic pressure drops to from 80 to 70 mm of mercury the basal metabolic rate also falls, and the tissues suffer from want of water food, and oxygen. Due to the anoxemia there is an incomplete combustion of fats and a consequent formation of non-respirable acids which pass into the blood and reduce the alkali reserve (111) Cannon has shown that in case of shock the amount of blood sugar is above normal and that there seems to be no relation between the carbon dioxid-combining capacity of the blood and the percentage of sugar present Scarpello (91) believes that the increase in blood-sugar is due to an alteration in the regulating function of the liver cells. The non-protein nitrogen content of the blood is increased blood chlorids are lowered, and the coagulability of the blood is reduced.

Management

Prophylactic Measures

Shock is a potential menace in every surgical procedure When once the condition is fully developed, irreparable damage to the vasomotor centers soon follows, and any or all treatment may fail Therefore, prophylactic measures should be instituted routinely before, during, and after all operations, and special precautions should be taken where the nature of the operation is such as to suggest its likelihood.

The factors demanding special attention in the prevention of shock are an accurate evaluation of the surgical risk, the preoperative recourse to measures designed to bring the patient's condition to an optimal state, a judicious choice and care in the administration of the anesthetic agent, the institution of protective measures during the operation, and painstaking postoperative care

Needless to say, except in the case of emergency surgery, an operation should be performed only after the patient's body chemistry has been brought as nearly as possible to normal. Patients with impaired circulation, diseased kidneys, defective liver function, diabetes, toxemia, and other debilitating conditions are especially liable to shock, and the control of these factors is considered in Chapter VIII Special precautions should be taken to guard against dehydration, reduced glycogen reserve, anemia, exhaustion, and loss of body heat Dehydration is averted preoperatively by the prescription of an adequate fluid intake, prevention of excessive perspiration, and the avoidance of saline cathartics If, however, the patient is already dehydrated, the condition is combated by the oral or parenteral administration of fluids, as described in Chapter V. The glycogen reserve of the liver should be increased to a maximum by means of a diet rich in carbohydrates (p 475) Anemia demands blood transfusions (p 470) If the patient is exhausted, every effort should be made to keep him quiet, since bodily activity will increase the oxygen demand on the already taxed tissues Under such circumstances even transportation should be avoided when possible

Loss of body heat is generally admitted to be a potent predisposing factor in the production of shock It is probable that cold increases the tendency to stagnation of the blood in the capillaries, increases its transudation through the blood vessels, and thus causes a further drop in blood pressure That cold is a factor in the production of shock is stressed by Cannon (19) who states "Members of shock teams working in the A E F during the summer and fall of 1918 reported the strikingly larger number and greater severity of the cases of shock in the cold, wet months of the fall, September and October, as contrasted with the cases seen during the fighting in the warm weather of July and August" In cases of potential shock the temperature is already subnormal, and any further fall due to unnecessary exposure or chilling will hasten the onset of actual shock Therefore, maintenance of body temperature is of the utmost importance Wet clothing should be removed and the skin dried with hot towels, hot drinks should be administered, and heat supplied by the use of hot blankets, electric pads, or hot-water bottles, wire-framed tents covered with blankets and heated by means of electric lamps may often be used to advantage The temperature of the operating room must be maintained at approximately 80°F, and undue exposure of the patient avoided (p 24). However, precautions must be taken not to overheat

the patient, since perspiration leads to dehydration, and the increased blood flow to the skin occasioned by the heat causes a further drop in blood pressure and a still greater diminution in the amount of blood sent to the heart.

In addition to the attention given to the patient's physical condition, there must be a corresponding consideration of his mental state, since psychic trauma, while intangible, exerts a powerful influence upon the bodily functions. Fright, worry, and anxiety may be relieved by reassurance. Sleeplessness and excitement can be overcome by the judicious use of barbiturates (p 398) The relief of pain is of paramount importance, since its persistence will lead to exhaustion. For this purpose morphin is often indispensible, for not only is it the most efficacious of all anodynes, but it serves to reduce the oxygen interchange in the tissues and at the same time conserves that of the blood and thus prevents a depletion of the alkali reserve. In addition, its soothing effect on the patient lessens the tendency to hemorrhage. However morphin should be withheld until after the diagnosis has been made, since its administration may mask the symptoms of the clinical picture. Small repeated doses are preferable to a single large dose, because of the depressing effect of the drug on the medullary centers which in the case of shock are already impaired.

The anesthetic agent must be selected with care and administered by a skilled anesthetist. The local anesthetics and nitrous oxid combined with 25 per cent oxygen are the agents of choice (p 425) Crile's anoci-association theory of the interception of violent afferent stimuli to the vasomotor center by means of local infiltration and nerve block of the operative field is clinically practical. O'Shaughnessy and Slome (78) suggest the use of spinal anesthesia for the control of the nociceptic impulses. It is questionable, however, whether it is wise to introduce a blood pressure lowering agent in a condition where the maintenance of a normal blood pressure is so important.

If the patient is already in a state of potential shock at the time he is observed, no surgery should be contemplated until the lowered blood pressure has been satisfactorily dealt with, since an ill timed operation may transform a state of mild shock into one of profound shock. He should be kept as quiet as possible and any unavoidable jarring or prolonged transportation reduced to a minimum Prompt control of hemorrhage by means of direct pressure or by the use of a tourniquet is imperative, since bleeding sensitizes to shock, and in the case of patients already in the potential stage a relatively small additional hemorrhage may prove fatal. Following hemostasis the wound is covered with a sterile dressing and given no further attention until the shock has been relieved. Before the removal of the tourniquet complete hemostasis should be obtained to prevent a fall in blood pressure. At one time this drop in pressure was thought to be due to the liberation of toxins from the injured tissues, but it probably results from hemorrhage following the release of the tourniquet. In the case of patients with extensive loss of blood a blood transfusion should be promptly given The body heat should be maintained (p 267), thirst assuaged by the administration of warm fluids and pain relieved with morphin.

Shock incident to operation can be prevented by careful surgical technic. The loss of blood can be minimized by the infiltration of the line of incision with procain, the judicious use of tourniquets planning the incision in such a way as to avoid large vessels, and by a progressive clamping of all bleeding points. Halsted frequently stated in his lectures that adequate hemostasis during operation was the most important

single measure to avert shock Unnecessary trauma can be eliminated by means of multiple-stage operations, incisions ample enough to avoid the necessity of retraction, clean division of the tissues with a sharp knife, gentle handling, and a substitution of mopping with gauze for wiping

While operations on patients in potential shock are generally to be avoided, there are circumstances which permit of no delay Obviously, in such cases the simplest procedure that will meet the requirements should be selected The patient's condition may be improved by means of a blood transfusion given preoperatively During the operation blood pressure readings should be taken every few minutes, and if the systolic pressure falls below 80 mm of mercury, additional transfusions should be administered while the patient is still on the table

Active Treatment

The therapeutic problem in shock, as has been said before, is to balance the disproportion between the blood volume and the vascular bed

Treatment of actual shock is directed toward (1) the relief of hypotension, (2) the decrease of capillary permeability, (3) the elimination of anoxemia, (4) the restoration of the acid base equilibrium, (5) the acceleration of metabolism, and (6) the stimulation of the cardiovascular and respiratory systems The proper measures should be instituted as soon as the blood pressure begins to fall If the low pressure is allowed to persist for any length of time, the consequent anoxemia may cause irreparable damage to the vasomotor center and invalidate all therapeutic efforts Scott and Cutler (94) believe that if the circulatory efficiency can be kept above the critical level and the blood volume maintained in the early stages before capillary permeability has been seriously increased, marked degrees of shock never ensue

As has been said before, the rate of decrease in the blood pressure is the best index to the severity of the shock and the most reliable guide in its treatment For this reason frequent readings should be taken As soon as the pressure begins to fall, compensatory mechanical measures to aid the circulation are indicated Elevation of the foot of the bed may prove helpful in bringing the blood to the medullary centers during the period of vasodilatation Crile advocates a bandaging of the limbs and compression of the abdomen to raise the blood pressure and has designed an inflatable pneumatic suit for the purpose The value of this apparatus is open to question

If the blood pressure continues to fall, a transfusion is administered This is the most effectual means of restoring the blood volume and of raising the pressure Its action is specific, and improvement is rapid It is especially indicated when hemorrhage was the initiating factor of the condition Seven hundred to 800 cc should be given as soon as the pressure falls to 80 mm of mercury If there is a subsequent decline in pressure, additional transfusions may be resorted to In the absence of a donor, an isotonic saline or glucose solution is administered intravenously as a temporary fortifying measure Isotonic glucose is preferable, because it not only increases the blood volume, but also aids in the correction of acidosis, promotes kidney function, and protects the glycogen reserve of the liver These isotonic solutions are capable of raising the blood pressure 15 to 30 mm of mercury within 4 or 5 minutes, but as they escape quickly from the blood vessels into the tissues through the damaged capillary walls, their effect is only transitory They should be introduced rapidly until

the blood pressure has risen to within 10 to 15 mm of normal at which time the flow is to be reduced to between 75 and 200 cc. per hour and continued at this rate until the clinical condition is satisfactory (p 366) In order to produce a more enduring effect on the blood pressure, Bayliss suggests the substitution of a 6 per cent acacia solution. The colloidal properties of acacia prevent its diffusion through the capillary walls and its osmotic quality causes it to draw fluid from the tissues into the blood stream, but despite these advantages its use is not unassociated with danger (p 357) If employed, 500 cc of a 6 per cent solution are introduced intravenously and this amount repeated in 2 hours if necessary

Frazer (34) believes that the slow administration of 10 per cent ethyl alcohol in a 10 per cent dextrose solution is effective in raising the blood pressure and states that following its administration patients experience a feeling of warmth and well being As much as 2 liters of this solution may be given intravenously in the space of 24 hours.

The use of hypertonic solutions has also been suggested. Simenauer (97) states that a hypertonic glucose solution when introduced into the circulation has a favorable effect on the heart and raises the blood pressure by withdrawing water from the tissues into the circulation He claims that 30 cc. of a 40 per cent solution of glucose have the same elevating effect on the blood pressure as 500 cc. of an isotonic solution. Hypertonic solutions however are of questionable value and may even prove harmful. While it is true that by their osmotic action they withdraw the tissue fluids into the circulation and bring about a rise in blood pressure, this increase is only transitory, inasmuch as the fluid is promptly lost by way of the kidney and the patient's condition is further jeopardized by the consequent dehydration of the tissues.

Acidosis must be combated, since there is evidence to show that the degree of shock bears some relation to the reduction in alkali reserve To increase this reserve Cannon (19) suggests the intravenous administration of sodium bicarbonate. However, care must be taken in its use to prevent an uncompensated alkalosis. Frazier (34) sees no advantage in bicarbonate solution and claims that similar benefits may be obtained from a 5 to 10 per cent dextrose in normal salt solution.

The depressed *respiratory and vasomotor centers* should be stimulated by inhalations of carbon dioxid and oxygen or by injections of coramin 1 cc. every 4 hours (110)

The use of drugs in the treatment of shock has proven generally unsatisfactory In primary shock the fall in blood pressure is probably due to a relative diminution of blood volume following a dilatation of the capillary bed. Theoretically, then, vasoconstrictor drugs would seem to be efficacious, but practically their value is questionable. A vasospastic drug elevates the blood pressure to some degree but the amount of blood mobilized by the slight increase in the peripheral resistance occasioned is not sufficient to relieve the anemia of the medullary centers In secondary shock these drugs are useless, since this condition calls for measures to increase the blood volume rather than raise the blood pressure Indeed, such drugs may be even harmful, since an elevation of the pressure in the presence of a small volume may further diminish the blood supply to the individual organs.

Of the vasoconstrictor drugs ephedrin hydrochlorid is the most effective as it raises the blood pressure and maintains it at a constant level for 30 to 60 minutes. It may be administered in the form of an infusion 0 065 gram (1 grain) of the drug combined with glucose 30 grams, gum acacia 35 grams, and distilled water to make 500 cc.

Adrenalin raises the pressure more quickly than does ephedrin, but its effect is of shorter duration. It is administered subcutaneously, intravenously, or injected directly into the heart muscle The latter method is known to be fraught with danger, since autopsies have revealed myocardial abscesses following such injections Furthermore, its injection into the heart seems useless, since the heart itself is not at fault.

In the absence of organic heart disease the use of cardiac stimulants is unnecessary, since in shock, as has been said before, the contractile power of this organ is unaffected Indeed, stimulants are often harmful, as they tend to drive more blood into the paralyzed capillary reservoir and further deprive the heart of its necessary supply Digitalis has been found to lower the minute cardiac output (10) Caffein has been employed intravenously, but its value is probably overestimated Swingle (101) and Freeman (35) suggest the use of cortico-adrenal hormone, as they believe that shock and adrenalin insufficiency have much in common, but there is no convincing evidence to show that this agent is of any benefit in the treatment of shock

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CHAPTER VII

ANESTHESIA

Surgeons of all times have labored earnestly in a search for an agent that would alleviate the pain attendant upon operation History records that the early Egyptian, Chinese, Roman, and Greek physicians endeavored to banish pain during surgery by recourse to potions and the fumes of various herbs, and by the employment of instruments made of precious metals Special analgesic properties were attributed to gold and silver, and tissues were supposed to be rendered less sensitive by the use of heated knives The application of cold for the relief of pain was recommended by Marco Aurelio, an Italian anatomist and surgeon of about the middle of the sixteenth century

Before the advent of anesthesia operative surgery remained a tragedy definitely limited to emergencies The only requisite in the performance of an operation was speed, indeed, the surgeon's skill was judged by the rapidity with which he carried out the operative procedure Students were exhorted not to "blink an eye for fear of missing the rapid stroke with which a limb was amputated" With the introduction of anesthesia in the middle of the nineteenth century the surgeon was enabled to work deliberately and cautiously and for the first time to acquaint himself with living pathology

The history of general anesthesia begins with the discovery of nitrous oxid by Priestly in 1774, but the use of this agent as an anesthetic was delayed until 1844, when Wells, a Connecticut dentist, employed it in the extraction of teeth Ether was first administered by Long (57) of Georgia in 1842 for the removal of a tumor of the neck, and after its public demonstration on October 16, 1846, by Jackson and Morton (50) at the Massachusetts General Hospital, it immediately gained popularity and still continues to occupy an important place in surgery In the same year the word "anesthesia" was coined by Oliver Wendell Holmes The following year (1847) chloroform was introduced in Scotland by Simpson (98) With the subsequent introduction of antisepsis and asepsis, and the reduction in morbidity and mortality which followed, a more ambitious surgery was attempted and as a result greater demands were made of anesthesia than mere muscular relaxation and relief of pain In order to meet these demands new anesthetic agents were synthetized in an endeavor to produce one that would provide absolute safety, insure complete relaxation, allow rapid and pleasant induction unassociated with excitement, permit of rapid return of consciousness and the cough reflex without unpleasant postoperative sequelae, and be non-inflammable and free from the danger of explosion While the ideal anesthetic has not as yet been evolved, there are many agents available, and by careful selection it is now possible, regardless of the patient's condition, to meet practically any operative need with a minimum of physiologic disturbance

Along with the synthetization of new agents more efficient methods of administration

were developed. Technics were elaborated to regulate the anesthetic concentration, to provide against the aspiration of foreign material and to permit of anesthetization with the anesthetist away from the field of operation. Among the more important advances were the perfection by Cotton and Boothby (23) in 1910 of the gas-oxygen and ether sequence machine, the introduction of the closed carbon dioxid absorption method by Waters (116) in 1926, the development of endotracheal anesthesia by Magill (71, 73) and Flagg (29), and the advent of intravenous and intraspinal anesthesia. One of the most recent contributions to the field of anesthesia has been the formulation of a rational pharmacologic basis for the production of preanesthetic sedation and basal narcosis

The history of local anesthesia begins with the perfection of the hypodermic syringe by Wood in 1853 Two years later cocain, the active principle of Erythroxylon coca, was isolated by Gaeleke, although there is evidence to indicate that the local anesthetic properties of this drug had been recognized by the Peruvian Indians much earlier Its analgesic properties were demonstrated by Bennet in 1874, and in 1879 von Aurup, having tried it on himself, suggested its use as a local anesthetic. Corning (22) was the first to make a clinical application of it in surgery It was not until 1884, however, when Koeller of Vienna reported his experimental and clinical results in ophthalmologic practice that it came into general usage. Its toxicity unfortunately limited its field of application. In 1903 Braun (15) demonstrated the fact that minute quantities of epinephrin added to the local anesthetic solution not only produced a bloodless field, but greatly prolonged the duration of anesthesia induced by infiltration and block injection. Thus bloodlessness was added to painlessness. Einhorn (26) in 1905 synthetized the relatively non toxic procain (novocain, neocain), and for the first time it became possible to operate safely without the necessity of rendering the entire body insensible. The use of local anesthesia has since been extended to operations on all parts of the body, including the cranial, thoracic, and abdominal cavities Credit for this expansion must be given to the pioneer work of Halsted, Cushing, Matas, and Braun, as well as to Lennander for his painstaking investigations in the field of sensory nerve distribution

CHOICE OF ANESTHETIC AGENT

The choice of the anesthetic agent and the mode of its administration are governed largely by the following factors

(1) **The Physical and Mental Status of the Patient.** The relation of anesthetic agents to the patient's physical and mental state has already been discussed in the section dealing with the surgical risk (Chapter VIII)

(2) **The Location of the Operative Site** In performing operations about the head and neck the anesthetist must necessarily be well removed from the operative field. In superficial operations this can be accomplished by recourse to procain infiltration, field block, or nerve block, but if local anesthesia is contraindicated, the endotracheal administration of nitrous oxid and oxygen or ether will be found convenient. The latter method is particularly applicable to operations about the mouth, as the pharynx can be packed off and aspiration of blood and septic material into the lungs thus prevented. For superficial operations on the thorax, such as rib resections, regional anesthesia will usually suffice, but for thoracoplasty the endotracheal administration of

nitrous oxid and oxygen, ether, or cyclopropane, is preferable For abdominal operations, where muscular relaxation is necessary, spinal analgesia with procain or the closed carbon dioxid absorption method with ether is indicated, unless the patient's condition is poor, in which event endotracheal nitrous oxid and oxygen supplemented by minimal amounts of ether or field block is advisable For operations on the upper extremities, infiltration or regional nerve block is usually resorted to, and for those on the lower extremities the choice rests between the above methods and spinal anesthesia

(3) ***The Nature of the Operation.*** If the contemplated operation is of a minor nature, the problem of anesthesia presents few difficulties, since the majority of these operations can be performed under a local agent, and the balance under nitrous oxid and oxygen Should muscular relaxation be required, it can be obtained by the use of the latter anesthetic as a base, supplemented either by minimal quantities of ether or by local nerve or field block or spinal anesthesia In the case of more severe operations, especially when the patient is a questionable risk, the choice of method will require a careful weighing of all the physical factors, inasmuch as each anesthetic agent and each mode of administration has its own particular indications, contra-indications, and limitations The problem will be to select the agent or combination of agents and the method of administration which will best meet the patient's individual need and still be consistent with surgical requirements For instance, while nitrous oxid is the safest general anesthetic, it does not induce muscular relaxation, and in certain operations, such as those on the abdomen, where relaxation is an essential requirement, it may prove more dangerous than a more toxic agent, because of its failure to provide the proper operative conditions In instances where cautery or diathermy is to be resorted to, a local anesthetic or non-inflammable inhalant gas, such as nitrous oxid, should be chosen when practicable But when the use of inflammable gas cannot be avoided, one must turn to the closed carbon dioxid absorption method, taking special care to fit the mask snugly over the face As an additional precaution the operating table should be grounded and the diathermy instrument polarized to prevent sparking

(4) **Facilities and Equipment** The facilities and equipment available must be given due consideration before the choice of anesthetic and its mode of administration can be decided upon For instance, when adequate equipment is lacking or a skilled anesthetist is not on hand, ether, while not the safest anesthetic agent, offers the greatest security

PREANESTHETIC SEDATION AND BASAL NARCOSIS

The development of agents capable of producing preanesthetic sedation and basal narcosis has contributed much to the comfort and safety of the surgical patient These drugs allay preoperative apprehension, permit of a more pleasant induction of anesthesia and, by reducing the basal metabolic rate and diminishing the demand for oxygen, make it possible to produce unconsciousness with minimal quantities of the anesthetic agent In addition they decrease the incidence of postanesthetic sequelae, such as vomiting, acidosis, pulmonary complications, shock, etc Indeed, in the case of nitrous oxid and ethylene administration, basal narcosis is often the only means of supplying an amount of oxygen sufficient to prevent anoxemia The light sleep following anesthesia is frequently prolonged for several hours, and the patient is thus spared much postoperative pain.

The principal disadvantage in the use of preanesthetic drugs lies in the difficulty of gauging the correct dosage and of accurately predicting the ultimate level of their action. Their depressing effect demands that they be used with caution in the aged, the debilitated, and in those suffering from hepatic renal, or pulmonary impairment. Furthermore, the prolonged suppression of the cough reflex may predispose to respiratory complications. Finally there is the danger of cumulative effects when supplemental sedative drugs are administered.

The essential difference between sedation and basal narcosis is one of intensity, sedation being merely a dulling of consciousness, and basal narcosis a state of insensibility bordering upon surgical anesthesia, but not so deep as to abolish entirely the perception of pain Therapeutically, basal narcosis lies between sedation on the one hand and surgical anesthesia on the other In the ordinary surgical patient preanesthetic medication carried to the stage of sedation is sufficient to allay the apprehension fear and worry inevitably associated with all operations, but in nervous individuals, in those whose previous experience with anesthesia has been unfortunate, and in psychiatric patients sedation is inadequate, and basal narcosis must be resorted to To such patients the thought of operation, the trip on the stretcher and the sight of the instruments are apt to assume exaggerated significance and may bring about reactions more deleterious than the operative trauma itself Frequently it is possible to narcotize these individuals surreptitiously in their rooms prior to operation so that they need not know when the ordeal is to take place or be aware of the journey to and from the operating room.

In the selection of the agent or combination of agents best suited to the individual need and in the calculation of the dosage which will bring about the desired effect, a comprehensive knowledge of the pharmacologic action and the methods of administering the various drugs is necessary since an alteration of the dosage or method of administration will induce different states of insensibility ranging from mental dulness to complete anesthesia. Sise (101) points out that "in general there may be said to be three stages to the effect produced as the dosage is increased In the first stage there is mild sedation The patient is conscious but is quiet and less apprehensive In the second stage the patient may or may not be conscious or amnesic but in either event he loses a certain amount of nervous control and co-ordination He may give way to his fear or be simply unco-operative He is often difficult to manage In the third stage the patient is deeply narcotized He is quiet, relaxed, usually unconscious or at least amnesic The first or third stages are aimed at, as the second is undesirable, especially if spinal or regional anesthesia is used. But the variation in the effect of a given dosage occasionally lands the patient in the second stage

Highly nervous patients and those suffering from pain require relatively large doses whereas the obese the debilitated and the aged, and those with low blood pressure demand a smaller quantity then do normal individuals because of their reduced metabolic rate. On the other hand, children young adults and those afflicted with toxic goiter have a higher tolerance and need comparatively large doses. Idiosyncrasy and tolerance to the drug also play a part individuals accustomed to narcotics require an increased amount while in those who have an idiosyncrasy even small quantities may produce toxic symptoms

In the choice of the appropriate drug the type of anesthesia to be employed is frequently a determining factor For operations requiring general anesthesia basal

narcotics are preferable, but for those to be performed under local anesthesia sedative agents are best. The latter not only induce calm and dull the perception of pain occasioned by the hypodermic needle, but also prolong the action of the procain by diminishing the individual's metabolic rate. Basal narcosis as a preliminary to local anesthesia is unsatisfactory, as the sleep it produces interferes with the patient's ability to co-operate, and with a lightening of the narcosis he may become uncontrollable.

SEDATION

The drugs most commonly used for the induction of sedation are (1) morphin, (2) omnopon, (3) hyoscin, and (4) the rapidly acting barbiturates, such as (a) pentobarbital sodium, (b) sodium amytal, and (c) luminal, which in addition to being sedative in nature are antidotal to procain.

Morphin. Morphin may be given in a single dose, ranging from 0.01 gram ($\frac{1}{6}$ grain) to 0.03 gram ($\frac{1}{2}$ grain), but is more safely administered in smaller divided doses, because in this way its effects can be better gauged and controlled, and if an idiosyncrasy is discovered, the drug can be replaced with another agent. However, it should be withheld in children under 5 years of age and restricted in the debilitated and those suffering from cardiac lesions. It is best given an hour before operation, to allow ample time for the production of its maximum effect and for the subsidence of the initial stage of excitement, which might otherwise impede the induction of anesthesia. Gwathmey (40) points out that the effects of morphin are enhanced by the addition of a chemically pure 0.25 per cent magnesium sulphate solution. One-eighth of a grain of morphin is dissolved in 2 cc. of this solution and given in two injections at half-hour intervals.

Hyoscin. Hyoscin, by depressing the cerebral cortex, induces a state of amnesia wherein the patient has no recollection of the operation and the immediate postoperative period. It is administered hypodermically in amounts of 0.0006 gram ($\frac{1}{100}$ grain) to 0.0004 gram ($\frac{1}{150}$ grain), and, like morphin, is best given in divided doses. It acts within 15 to 20 minutes and its effects last for 5 to 6 hours. While in some patients the results are ideal, unfortunately its use is limited, due to the variability and uncertainty of its action.

Barbituric Acid Derivatives. A large number of barbiturates have been synthetized and used as hypnotics. Although they vary widely in their pharmacologic action, they have certain characteristics in common. They produce hypnosis but are not analgesic, and in the presence of pain may cause excitement. Their principle disadvantage lies in the variability of their action. These agents are absorbed in the gastro-intestinal tract. They lower basal metabolism, diminish the output of urea, and depress the respirations, heart action, and blood pressure, the degree of depression depending upon the dose and the mode of administration. They do not give rise to hemolysis or agglutination of the erythrocytes. They effect a slight increase in the blood-sugar but cause no change in the bilirubin content of the blood serum. Watkins calls attention to the danger of granulocytopenia following the use of these agents, but recently the Council on Pharmacy and Chemistry of the American Medical Association (88) reported that there was no evidence to prove that the barbiturates are an etiologic factor in the production of this disease. Lundy (66) and Eisenberger have demonstrated the fact that these drugs are antidotal to procain. Therefore,

they are especially valuable when used prior to the administration of a local anesthetic. They may be given orally, rectally, or intravenously, but for purposes of sedation the oral method is the most satisfactory

The barbiturates most frequently used are (1) pentobarbital sodium (nembutal), administered in capsules of 0 10 to 0.20 gram (1½ to 3 grains) This drug is less stable than sodium amytal, hence, it is more rapidly detoxified, shortens the period of hypnosis, and diminishes the tendency to postanesthetic restlessness Because of its less toxic action it is particularly suited to children. (2) Luminal, in doses of 0 065 to 0 13 gram (1 to 2 grains) It acts within ½ to 1 hour and its effects last from 4 to 6 hours (3) Sodium amytal, in 0.2 to 0 4-gram (3 to 6-grain) doses

While no single drug or combination of drugs, in view of the many factors which influence their action, can be used routinely in all cases, the following plan will serve as a basis for preanesthetic sedation On the night before operation, one hour before retiring, the patient receives 1 to 2 capsules (0 10 to 0.20 gram, or 1½ to 3 grains) of pentobarbital sodium. On the following morning, one hour preceding operation, the same dose is repeated, and in addition he is given a hypodermic of morphin 0 01 to 0 016 gram (⅙ to ¼ grain) and hyoscin hydrobromid 0 0004 gram ($\frac{1}{150}$ grain) If a general anesthetic is to be used, the hyoscin hydrobromid is replaced with atropin 0 0004 gram ($\frac{1}{150}$ grain) in order to check the bronchial secretions. The advisability of resorting to atropin as a routine measure prior to general anesthesia has, however, recently been opened to question. It has been asserted that the subsequent dryness of the mouth is distressing to the patient, and that the inspissation of the secretions and retardation of the ciliary activity of the respiratory tract caused by this agent tend to favor retention of the bronchial discharges If the patient is a child under the age of 5 years, or is aged and debilitated, morphin should be withheld, and the dose of pentobarbital sodium reduced to 1 grain and administered either orally in the form of a small capsule, or rectally as a suppository With the above premedication the patient will reach the operating room in a state of drowsiness and will be left with no clear recollection of the ordeal.

Basal Narcosis

Avertin (Tribromethylalcohol, Tribromethanol) The agent most commonly employed for the induction of basal anesthesia is avertin. This drug was synthetized in Germany by Willstaetter and Duisberg in 1923 and in 1926 Eicholtz (126) suggested its use for anesthetic purposes. It was first used in the United States in 1929 (37) and has since supplanted colonic ether-oil. From the patient's standpoint, it is the most tolerable basal anesthetic. It is a white crystalline solid, sparingly soluble in water, derived from yeast fermentation of bromol, and is marketed in solutions of amylene hydrate, called 'avertin fluid," each cubic centimeter of the liquid containing 1 gram of the drug (123, 106) It is rapidly absorbed through the mucosa of the lower bowel. Straub found that 80 per cent of it was absorbed in the first 20 minutes and 95 per cent within the first 2 hours. In the body it combines with glycuronic acid and is eliminated in this form by the kidney It produces unconsciousness, together with considerable muscular relaxation lasting for several hours. It is a respiratory and circulatory depressant, causing the breathing to become slow and shallow

and the blood pressure to fall 10 to 20 mm of mercury It has no effect on the parenchymatous organs, except to induce a slight, transitory diminution of renal and hepatic function, associated with an increase in blood-sugar and a slight degree of acidosis When used as a preliminary to gaseous agents, such as nitrous oxid and oxygen, ether, or vinethene, avertin increases the rapidity of induction, insures a more complete relaxation, and permits of the maintenance of anesthesia with minimal quantities of the anesthetic agent

Avertin is contraindicated in cases of severe disease of the liver and kidney, although it is less damaging to the liver than ether or chloroform It should be avoided in the presence of pulmonary disorders, because of its depressing effect on the respiration, and it is not advisable in shock and hemorrhage, since it lowers the blood pressure For obvious reasons it is not applicable for patients suffering from ulcerative diseases of the rectum and colon

Avertin is given rectally as a 2 5 per cent solution in distilled water The dosage is regulated by the patient's weight, age, physical condition, and metabolic rate, the average prescription ranging between 50 and 100 mg per kilogram of body weight In the mixing and administration of the solution the printed directions on the package must be rigidly followed Before its introduction, it should be tested with congo red for the presence of impurities which might irritate the intestinal mucosa A warning has been issued by the manufacturers of the drug that the maximum total dose for women should not exceed 8 cc , and for men, 10 cc

On the evening prior to operation an enema is given, and on the following morning, one hour before operation, 0 01 gram ($\frac{1}{6}$ grain) of morphin is administered hypodermically A half hour later the avertin solution is introduced into the rectum at body temperature through a small rectal catheter, 10 minutes being allowed for the process In the case of children a urethral syringe may be employed Slow injection is essential in order that any possible idiosyncrasy may at once be detected In such an event the introduction can be discontinued before the full quantity has been given, and thus serious toxic effects will have been prevented Unconsciousness begins on an average of 7 minutes following the administration of the solution and is not attended with excitement The maximum narcotic effects are obtained in 20 to 30 minutes and last for $1\frac{1}{2}$ to 2 hours, after which time the patient passes into a light sleep of several hours' duration Evidences of an overdose will be manifested by anoxemia, cyanosis, and respiratory and circulatory failure Should such symptoms arise, breathing may be stimulated by means of intramuscular or intravenous injections of 1 to 2 cc of coramin, and by inhalations of oxygen and carbon dioxid, while the circulation may be re-established by warm applications and external friction During the stage of recovery the patient should be carefully watched by a trained attendant, special precautions being taken to guard against respiratory difficulty resulting from the falling back of the tongue into the pharynx

Paraldehyd. Paraldehyd is a colorless liquid with a repulsive taste and odor It is a powerful, rapidly acting hypnotic, and the margin of safety between the effective and the dangerous dose is wide The average dose will not depress the circulation or the respiration The chief objections to its use are its prolonged action, its offensive smell, and the occasional excitement of the patient during its induction and at the time of awakening It is administered in a 10 per cent solution of normal salt, 4 cc of

paraldehyd being allowed for each 15 pounds of body weight. The total dose should never exceed 30 cc. It should be given about ¾ of an hour before operation in the form of a retention enema the fluid being introduced slowly at body temperature Its effects appear in 35 to 40 minutes. It is especially efficacious in children, in alcoholics and in patients suffering from respiratory disorders.

LOCAL ANESTHESIA

The ability to limit analgesia to the operative field without the necessity of desensitizing the entire body has contributed much to the comfort of the surgical patient and the convenience of the surgeon. Since its introduction the method has become increasingly popular, and in the past few years its scope has been broadened to include operations on all parts of the body A report made at the Mayo Clinic disclosed the fact that in a period of 4 years local analgesia was employed in part or whole in over 50 per cent of patients operated upon

Success in the use of a local anesthetic demands a thorough conception of the anatomy and physiology of the part to be anesthetized, a proper selection of the patient, an adequate knowledge of the pharmacology and toxicology of the drug, and skill in its administration.

Anatomy and Physiology of Operative Site In order to block off completely every avenue of pain it is necessary to visualize the distribution and surface landmarks of the related sensory nerves A knowledge of the degree of sensitivity of the various tissues of the body is also essential Skin, mucous membrane, muscle sheaths perichondrium, and periosteum are extremely sensitive fat and muscle are less so, while cartilage bone, and bone marrow as well as the pachymeninx, brain, and abdominal viscera, are practically devoid of sensation Sensitivity to pain is generally increased in the presence of inflammation and diminished in edematous, neoplastic, and granulomatous tissue.

Selection of Patient In the selection of the patient, the indications, contraindications, and limitations of local anesthesia must be carefully weighed Since it has virtually no toxic effect on the various organs of the body it is therefore especially applicable to the aged, the obese and patients suffering from circulatory disturbances, renal insufficiency, and respiratory conditions. Generally speaking, local anesthesia is preferable to general owing to its safety economy, and convenience. It is especially useful when the surgeon is compelled by circumstances to work single handed and when the patient has an unreasoning fear of a general anesthetic. By blocking the nocuous centripetal stimuli it reduces the incidence of shock no special preoperative preparation is required and the diet and fluid intake do not have to be disturbed. Details of technic need not be sacrificed, since prolonged operation under local anesthesia involves little risk. The patient, being conscious, is in a position to co-operate —an item of distinct advantage in the application of casts and splints and for x ray control during operation Postoperative restlessness, sweating vomiting and bowel disturbance which follow general anesthesia are minimized. When used in combination with a general anesthetic it serves not only to minimize shock but reduces capillary oozing, and permits of the use of smaller doses of the general agent.

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Success in the use of a local anesthetic demands a thorough conception of the anatomy and physiology of the part to be anesthetized, a proper selection of the patient, an adequate knowledge of the pharmacology and toxicology of the drug, and skill in its administration.

Anatomy and Physiology of Operative Site. In order to block off completely every avenue of pain, it is necessary to visualize the distribution and surface landmarks of the related sensory nerves. A knowledge of the degree of sensitivity of the various tissues of the body is also essential. Skin, mucous membrane, muscle sheaths, perichondrium, and periosteum are extremely sensitive, fat and muscle are less so, while cartilage, bone, and bone marrow, as well as the pachymeninx, brain, and abdominal viscera, are practically devoid of sensation. Sensitivity to pain is generally increased in the presence of inflammation and diminished in edematous, neoplastic, and granulomatous tissue.

Selection of Patient. In the selection of the patient, the indications, contraindications, and limitations of local anesthesia must be carefully weighed. Since it has virtually no toxic effect on the various organs of the body, it is therefore especially applicable to the aged, the obese, and patients suffering from circulatory disturbances, renal insufficiency, and respiratory conditions. Generally speaking, local anesthesia is preferable to general, owing to its safety, economy, and convenience. It is especially useful when the surgeon is compelled by circumstances to work single-handed and when the patient has an unreasoning fear of a general anesthetic. By blocking the nocuous centripetal stimuli, it reduces the incidence of shock; no special preoperative preparation is required, and the diet and fluid intake do not have to be disturbed. Details of technic need not be sacrificed, since prolonged operation under local anesthesia involves little risk. The patient, being conscious, is in a position to co-operate—an item of distinct advantage in the application of casts and splints and for x-ray control during operation. Postoperative restlessness, sweating, vomiting, and bowel disturbance, which follow general anesthesia, are minimized. When used in combination with a general anesthetic it serves not only to minimize shock, but reduces capillary oozing and permits of the use of smaller doses of the general agent.

Local anesthesia, however, has its limitations. It may not be suited to the age and

temperament of the individual It is impracticable for children who are too young to cooperate Yet it must be said that some children display great fortitude, and each case will have to be decided on its own merits Patients who have passed sleepless nights, those who, either because of fear or because of some previous uncomfortable experience, dread operation, and those who cannot bear the sight of surgical instruments or blood and are suspicious regarding every move that the operator makes, are also poor subjects for local anesthesia Under such circumstances the operative technic is interfered with, as the surgeon will be obliged to expend his energy in upholding the patient's morale

Local anesthesia is likewise contraindicated if the operative site is inflamed, infected, or of low vitality In inflamed tissue the associated local acidosis will prevent the absorption of the anesthetic agent, and in the presence of infection the pressure of the liquid may result in a spreading of the process If the nutrition of the operative site is defective—for instance, in flap operations in which large masses of tissue are separated from their blood supply, or in angiospasm and thromboangiitis obliterans—it is better to use a general anesthetic, as the edema consequent upon the use of a local agent may further impair the circulation of the part Moreover, the operative area may be so extensive as to be beyond the control of a local agent Another disadvantage is the distortion of the part which follows direct infiltration, although this objectionable feature can be overcome by recourse to nerve blocking

Procain

The ideal local anesthetic agent is one that incorporates the following properties: (1) non-toxic and non-irritating, (2) capable of producing anesthesia quickly and completely and of maintaining it for a time sufficient to carry out the necessary operative procedure, (3) capable of sterilization without risk of deterioration, (4) soluble in water, and (5) compatible with vasoconstrictor agents

While such an agent is still but a hoped-for objective, *procain* most nearly fulfils the above requirements, and this fact, together with its additional efficacy when combined with epinephrin, has given it universal popularity (1) It is relatively non-toxic, being only one-tenth as toxic as cocain, and hence its use in large doses is comparatively safe (2) It is rapidly and completely absorbed, no trace of its passage being left at the site of injection (3) Because its melting point is 156°C, it can be sterilized in an autoclave at 110°C, with no risk of deterioration, furthermore, the sterilization process can be repeated several times without destroying its anesthetic properties (4) It is completely soluble in isotonic sodium chlorid and Ringer's solutions and may be fortified with epinephrin without danger of decomposition (5) Locally it does not irritate the tissues, and systemically it causes no appreciable functional impairment of the heart, liver, kidneys, gastro-intestinal tract, or bladder, consequently, it affords a greater degree of comfort after operation than does a general anesthetic

Pharmacognosy

Einhorn (26) of Germany (1905) synthetized para-amino-benzoyldiethylamino-ethanol hydrochlorid and gave it the name of "novocain" Under the Trading with

Enemy Act the Federal Trade Commission appropriated the patent and issued licenses to United States pharmaceutical concerns for its manufacture, with the provision that the product be identical with that formerly made in Germany, and that it be called "procain." The French brand is known as "neocain," and the British variety, "anocain."

(1) **Chemical Properties** Procain is a white odorless crystalline substance, one gram of which is soluble in 0 6 cc. of water and 30 cc. of alcohol. Its aqueous solution is slightly antiseptic. It is incompatible with alkalies, phenol, mercurial salts, and alkaloidal precipitants. Procain, when mixed with epinephrin solution, is acid in reaction, with a pH of 5.3 There is evidence to show that a relationship exists between the pH of the procain epinephrin solution and its anesthetic efficacy Within given limits, the more closely the pH of the procain solution can be made to approximate that of the blood, the speedier will be the induction of anesthesia and the less pronounced the tissue irritation, pain, and edema. This is attributed to the fact that the procain base is more readily dissociated in an alkaline than in an acid solution. On these grounds Benedict (9) suggests the addition of an alkali to the procain epinephrin solution in order to increase its effectiveness. Braun uses a 0 4 per cent solution of potassium sulphate in normal salt. Sollman (104) proved that the addition of sodium bicarbonate increased the anesthetic properties of procain 8 times when injected into motor fibers and 2 to 4 times in sensory fibers. However, the limit of efficacy of alkaline solutions is attained when the pH reaches 8 4, beyond this point the solution is rendered too unstable for practical purposes.

(2) **Preparation.** Procain is marketed in tablet form in combination with epinephrin, and also as a solution in sealed ampules. For ordinary use either one of these forms is convenient, but in large institutions where great quantities of the anesthetic are employed, it has been found more satisfactory and economical to prepare the solution in bulk The 1 per cent solution is prepared as follows 720 cc. of distilled water are filtered into a flask, a sufficient number of Ringer's tablets being introduced to make the solution isotonic, 7.2 grams of procain crystals are then added and the mixture is heated in an autoclave for 30 minutes under standard pressure The solution should be kept in a dark room when not in use. While it may be stored for a considerable time without danger of undergoing deterioration, it is advisable to replace it after several weeks with a freshly prepared supply Sodium bicarbonate is incompatible with procain, and for this reason containers and syringes with which it comes in contact should be thoroughly boiled in distilled water and subsequently washed for the removal of all traces of alkali Because epinephrin is decomposed by prolonged boiling, it should be added to only that portion of the solution removed from the flask for immediate use. If, after the introduction of epinephrin, the solution becomes brownish in color, it should be discarded

Pharmacodynamics

(1) **Absorption and Elimination.** Procain is rapidly absorbed in the tissues. That part which reaches the blood stream is soon reduced to innocuous substances in the liver (44) Very little, if any is excreted by the kidney This rapid destruction probably accounts for the body's tolerance of large doses of the drug

(2) **Action on Peripheral Nerves.** Procain temporarily paralyzes the peripheral

sensory arborizations, nerve trunks, and nerve cells in the infiltrated area, abolishing functional activity and interrupting the passage of afferent impulses as if the nerve were cut The nerve endings are paralyzed more completely than the fibers, and sensory nerves more completely than motor nerves or those controlling touch This explains the retention of the tactile sense despite the loss of pain sensations Voluntary motions, being activated along a separate nerve pathway, remain unimpaired Analgesia begins almost immediately after the injection but is not complete until 10 or 15 minutes have elapsed The pharmacologic action of procain is probably associated with a hydrolysis of the local anesthetic agent by the alkali present in the tissue fluids, the procain thus liberated from its solution being taken up by the nerve structures

(3) **Systemic Action** Although procain is not a derivative of cocain, it has been demonstrated experimentally that its general physiologic action differs only in degree, its toxicity being one-tenth that of cocain Following the injection of a physiologic dose of procain and epinephrin, either intravenously or subcutaneously, no functional changes are observable in the heart, liver, kidney, or lung, and the blood pressure remains practically the same, although the readings may show slight fluctuations which are of little or no significance

Toxicology

Under average conditions the toxicity of procain is negligible, provided the drug is given in proper doses, but there is always the possibility that the patient may possess an idiosyncrasy, and in such cases even as little as 0 5 cc of a 0 5 per cent solution has been known to produce toxic symptoms In view of this fact, a "safety pause" should be made after the injection of the first few drops of the solution, to allow time for toxic manifestations to develop, before the total quantity has been introduced When a definite history of an idiosyncrasy exists, the patient's sensitivity to the drug should be ascertained by means of a patch test before the injection is begun It is difficult to estimate the toxic dose of procain, as the effects of the agent vary markedly with the skill with which it is administered and the condition of the patient The toxic action may be brought about by (1) Inadvertent introduction of the drug into the circulation, intravenous injections being ten times more poisonous than subcutaneous Lundy (64) cites the case of an adult woman "who was thrown into a convulsion by the intravenous injection of 3 cc of a 1 per cent solution of procain hydrochloride, yet this patient tolerated the average amount of the drug when subsequent injection was carried out with the careful avoidance of intravenous injection" (2) Too rapid introduction of the agent into the tissues and too great a concentration of the solution The danger of intoxication bears a closer relationship to the rate of absorption than to the size of the dose The toxic action is in geometric ratio to its concentration, thus the total amount of the drug required for the production of a toxic effect is many times greater in a weak than in a strong solution (3) The presence of epinephrin There is evidence that would make it appear that the toxic symptoms are due to the epinephrin rather than to the procain (4) The use of deteriorated solutions

Toxic symptoms are manifested by a feeling of apprehension, restlessness, faintness, rapid pulse and respirations, dyspnea, cyanosis, tremors, nausea, and cold sweats

If the dose is overwhelming, these signs are followed by respiratory depression, accompanied by Cheyne-Stokes respiration, a rapid fall in blood pressure, and cerebral symptoms, such as delirium, convulsions, and possibly coma and death.

Treatment of Toxic Symptoms At the first sign of toxicity the introduction of the anesthetic is to be discontinued and further absorption prevented by the application of a tourniquet above the injected area, the pressure being released gradually as the symptoms disappear If the area has been incised, it will be well to promote bleeding Should the symptoms persist, the patient is placed in the Trendelenburg position, heat applied, artificial respiration instituted, and oxygen and carbon dioxid administered. The barbiturates are antidotal to procain, and therefore luminal 0 065 to 0 13 gram (1 to 2 grains) or some other one of these agents should be given hypodermically Convulsions may be controlled by inhalations of ether or amyl nitrite pearls 1 to 2. Cardiac stimulants, such as caffein 0.25 gram or coramin 1 to 2 cc., may be administered hypodermically if necessary

Dosage

The determination and regulation of the amount of procain to be used in a given case will depend upon the individual tolerance of the patient and upon the quantity, concentration, and rate of absorption of the solution. The patient's tolerance is estimated by his age, weight, blood pressure, hemoglobin, and pulse rate. According to Lundy, a person between the ages of 25 and 50, of normal weight, blood pressure, hemoglobin, and pulse rate represents average tolerance, and the greater the variation in these respects, the lower the tolerance. The rate of absorption depends upon the strength of the solution. The more concentrated the solution, the more rapid the absorption. Thus 300 cc. of a 0.5 per cent solution is safer than 75 cc. of a 2 per cent solution, even though in both instances the same quantity of the drug is injected. The minimal lethal dose has been calculated at 50 mg per kilogram of body weight. Generally speaking, procain hydrochlorid in a 0.5 per cent solution may be given in amounts up to 500 cc. to good risks, up to 300 cc. to fair risks, up to 200 cc. to poor risks. In this concentration it is indicated for children, for adult poor risks, and in cases where the operative site is extensive. But since such a low concentration necessitates the injection of a large quantity of fluid, it tends to distort the operative field and, by pressing on the surrounding structures, may interfere with the circulation of the part. Procain in a 1 per cent solution may be given in doses up to 150 cc to good risks up to 125 cc. to fair risks, and up to 100 cc. to poor risks. This concentration is preferable when smaller amounts of the drug are to be used since it minimizes the distortion of the tissues. Procain in a 2 per cent solution may be given in doses up to 60 cc. to good risks up to 40 cc. to fair risks, and up to 30 cc. to poor risks. This concentration is particularly suitable for nerve blocking and while it is more toxic than a weaker solution on the other hand a smaller quantity is required for the induction of anesthesia.

Lundy (66) offers a formula which may be taken in a general way as an index to the dosage of procain

$$\frac{``CA}{RT} = \text{Reaction}$$

C is the concentration of the procain hydrochloride solution, A the amount of solution, R the time consumed for injection, and T the patient's tolerance for the drug under the circumstances of its use in a given instance If this index assumes too large a value, an untoward reaction results"

Vasoconstrictors

The addition of a vasoconstrictor agent to the local anesthetic solution serves to confine the action of the anesthetic to the injected area, thus prolonging its effect and permitting of the use of smaller quantities of the agent in weaker concentration, furthermore, it affords the surgical advantage of a bloodless field Vasoconstrictor agents, however, are not entirely free from danger Due to their tendency to interfere with the circulation, they must be withheld in the case of patients showing a predisposition to vasoconstriction, and should be used with caution in certain regions of the body, such as the fingers and toes The rise in blood pressure which they occasion interdicts their administration to individuals suffering from hypertension, diabetes, and severe heart disease Another undesirable feature of these agents is their proneness to induce a secondary hyperemia and cause postoperative oozing

Among the vasoconstrictor agents the most efficacious are (1) epinephrin, (2) cobefrin, and (3) ephedrin

(1) **Epinephrin.** Epinephrin is the active principle of the medulla of the suprarenal gland It was first isolated in 1897 by Abel, who gave it the name "epinephrin," and was first obtained in crystalline form in 1901 by Takamine, who patented it as "adrenalin" Its other trade names are "suprarenin" and "adrenin" From the standpoint of local hemostasis, epinephrin is the most useful of the vasoconstrictors It acts directly on the sympathetic nerves of the blood vessels, causing a vasoconstriction followed by a rise in blood pressure and cardiac acceleration Its action lasts about 15 minutes In susceptible individuals it frequently produces toxic symptoms, notably pallor, anxiety, tremors, nervousness, and cardiac and respiratory distress These effects, however, are transitory and can be considerably mitigated by the use of small doses and slow introduction of the solution If toxic symptoms supervene, the injection is discontinued until they disappear. Ordinarily the subsequent injection will cause no further reaction, possibly because the first injection created a tolerance for the drug

Epinephrin under the trade name of "adrenalin" is marketed as a 1.1000 solution of the hydrochlorid in physiologic normal salt solution. One minim (0 065 gram) of adrenalin to every 2 cc of procain solution makes a dilution of 1 in 30,000 The amount of adrenalin should be kept at a minimum, not only because of its toxic effect but also because of its low pH content of 3 3 As has been said before, the acidity of the epinephrin lowers the pH of the anesthetic solution and thus reduces its efficacy Serafin (97) has reported that a concentration of 1:20,000 epinephrin in a 2 per cent cocain solution is capable of producing local necrosis of tissue. Sollman (105) is of the opinion that the maximum concentration should not exceed 1:50,000, and Mayer believes that the total dose should not be above 1 mg. Because of its potency, epinephrin should be added to the procain solution by the surgeon himself and preferably from sterile ampules

(2) **Cobefrin.** Cobefrin is one of the more recently evolved synthetic vasocon-

strictors. Its physiologic action is similar to that of epinephrin, but its effect is more lasting. Moreover it is said to have a less unfavorable influence on the heart and blood pressure than epinephrin. Tainter (110) has shown that it is much less toxic than the latter agent and may be used in much weaker concentration. Winter (125) cites experimental evidence to indicate that procain plus epinephrin is more toxic than the same concentration of procain with 5 times the quantity of cobefrin. Cobefrin is used in a concentration of 1 200,000 to a 1 per cent solution of procain, and 1 400,000 to a 0.5 per cent solution of procain (65)

(3) Ephedrin. The action of ephedrin is similar to that of epinephrin and its effect is more prolonged, but it is not as efficacious a vasoconstrictor and does not satisfy the demands for local anesthesia. Its principal indication is for the maintenance of the blood pressure in spinal anesthesia (p 421)

Complications Following Local Anesthesia

Complications following the induction of local anesthesia are usually of a minor character and may be prevented if the proper precautions are taken in the preparation of the patient the solutions, and the instruments. Highly nervous individuals sometimes develop neurogenic shock even before the needle has been introduced. This syndrome may be avoided by adequate psychologic management and preanesthetic medication and by covering the eyes and plugging the ears prior to operation. Once the symptoms have developed, they can usually be relieved by the inhalation of a few drops of amyl nitrite or the oral administration of a dram of aromatic spirits of ammonia in a little water. Ordinarily the operation may be continued immediately after the patient has rallied from the shock.

The breaking of the hypodermic needle in the tissues is not an uncommon accident and may be due to the use of a rusty needle, to undue bending of the instrument during its introduction, or a sudden movement on the part of the patient. While the broken fragment may give rise to no immediate symptoms, it is a source of considerable concern because of its tendency to migrate and puncture some distant part of the body. For this reason attempts should be made to recover it immediately after the mishap occurs. If the fragment is lost in the tissues it is essential that it be positively localized before any attempt is made to remove it. A useful method of determining its position is the insertion into the part of a long needle aimed to strike the middle of the broken one. A second needle is then passed at right angles to the first, and the relationship between the two checked by means of anteroposterior and lateral roentgenograms. If the guide needles are found to be wide of the mark, they are removed and reinserted, and more films are made. As soon as the location of the fragment is established the the tissues are divided layer by layer and when the needle is reached, it is picked out with a hemostat. A powerful magnet may be of assistance in case the needle is made of steel.

If during the introduction of the anesthetic a blood vessel is inadvertently punctured, a hematoma will appear at the site of injection. If small it will disappear of its own accord, but its absorption can be hastened by the application of cold and a pressure bandage. Large hematomata however may necessitate prompt evacuation. Following injections in areas where the circulation is faulty, the part sometimes assumes a cadaveric pallor. Should this occur an effort should be made to re-establish the

circulation by means of hot and cold compresses and massage Local postoperative pain can usually be traced to the introduction of a non-isotonic solution or to one containing some irritating agent Relief is usually afforded by the application of heat or by the administration of 0 6 gram (10 grains) of aspirin, repeated in 3 hours if necessary Local congestion is a natural reaction to the vasoconstricting effect of epinephrin and ordinarily manifests itself within 2 hours following the injection, but the condition disappears spontaneously and requires no treatment Neuritis and temporary paralysis are occasional sequelae, being due to injury of the nerve by the needle or to the presence of alkali in the syringe at the time of injection Some of the later possible complications include infection, sloughing, and necrosis resulting from errors in aseptic technic, the use of stale or contaminated solutions, irritating chemicals, or the introduction of the anesthetic solution into a focus of infection

Technic of Administration

The aim of local anesthesia is to procure complete local insensibility, to provide a blanched field, to prevent distortion of the tissues, and to avoid the injection of an appreciable quantity of the agent into the circulation

Preliminary Management The preliminary preparation for local anesthesia is essentially the same as that for general anesthesia, except that the stomach need not be empty, indeed, a little food administered an hour or so before operation may be of benefit, inasmuch as hunger is not conducive to patience and courage Every patient is more or less apprehensive and expects to be hurt, and although his confidence can never be absolutely secured, much can be done to relieve anxiety by tactful psychologic management on the part of the surgeon and personnel, and by adequate premedication It may reassure him to be given to understand that at any time a gaseous anesthetic is at his command The details of the operation itself should be passed over lightly, so that he may feel by implication that a matter so trivial merits little discussion A self-contained and confident manner on the part of the surgeon will do much to set a patient's mind at ease During the induction of anesthesia his attention may be diverted from the procedure by means of conversation along the line of one of his leading interests Inasmuch as he remains conscious, he will be cognizant of all that is said and therefore, lest he misinterpret what he hears, attempts should be made to reduce external impressions to a minimum The eyes should be covered and, if necessary, the ears plugged with cotton The personnel must be instructed to refrain from comments on the patient's condition and to avoid unnecessary talk and noise in his presence Best (10) makes an interesting suggestion for diverting the attention of dental patients by means of a "radio chair" which might well be adapted to surgical purposes "While the unit is in operation no music is audible to anyone in the office, aside from that obtained when the head is placed in the headrest In the left arm of the chair is built a volume control button so that the volume of music can be raised or lowered by the patient . The music is obtained by a mechanical record-changing device which at present will play six or seven large sized records with one loading The music is transmitted to the radio and from this, by a readjustment of the wiring, it is carried by cables to the various headrests "

No indication should be given of the beginning of the operation Instruments should be called for by signs (fig 5) or referred to by names unfamiliar to the patient

For instance, when a knife is required, the surgeon may go through the motions of cutting or ask for a "Bard Parker" Questions such as "Does it hurt?" or "How are you feeling?" are suggestive and should be avoided. Above all, repeated assurance on the part of the surgeon that he will not hurt and frequent assertions that he has nearly finished should be eschewed, as they destroy the patient's confidence In the course of a prolonged operation, however, or during brief periods when painful manipulation is unavoidable, a judicious word will sometimes be encouraging Should the patient complain of pain at any time, the operation must be immediately discontinued and the part desensitized.

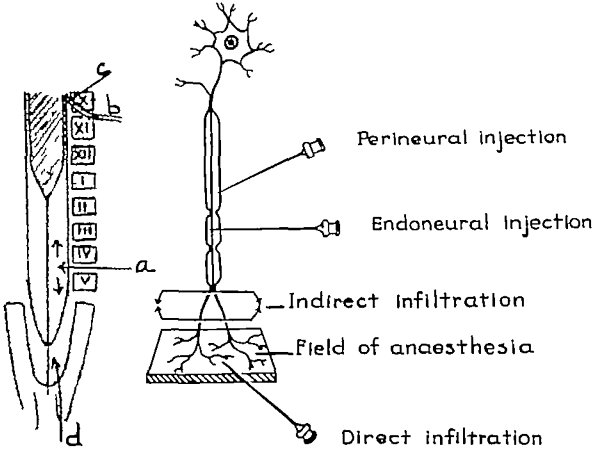

Fig. 192. Types of local anesthesia. *a* subarachnoid. *b* paravertebral. *c* peridural. *d* epidural. (Roux)

Instruments and Asepsis. Simplicity of armamentarium and strict asepsis are essential. All syringes, needles, and solutions must be carefully checked before they are used, to ascertain their efficacy

(1) *Syringes* A great variety of syringes have been devised for the introduction of the anesthetic solution, but the choice of the type to be used is immaterial, provided the following requirements are met (a) The plunger must fit snugly; (b) it must be supplied with a lock which holds the needle in position accurately and firmly to insure against slipping and leakage under pressure, (c) it must be of such size and shape as to facilitate manipulation and (d) it must be made of glass to permit of easy sterilization. Formerly when pressure was deemed a necessary factor in the introduction of the anesthetic solution the all metal syringe was believed to be indispensable. But the

introduction of the anesthetic under pressure is now considered objectionable, and the all-metal syringe has therefore been largely discarded For ordinary purposes a Luer all-glass syringe of a 10 to 20 cc capacity is satisfactory (fig 193a) It can be

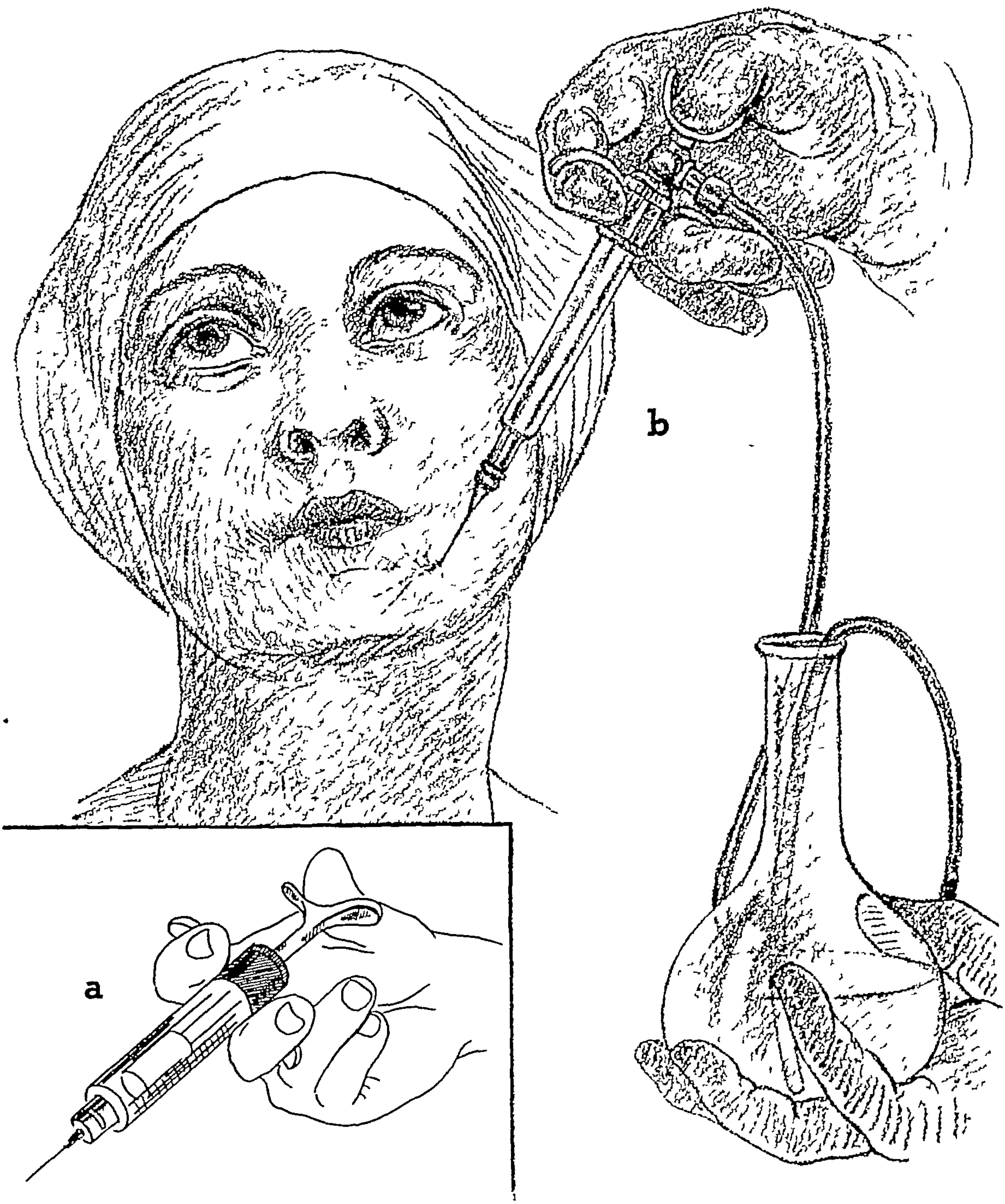

FIG 193 Syringes for introduction of local anesthetic *a*, Luer all-glass syringe, type used for ordinary purposes *b*, Pitkin's continuous-flow syringe, for extensive infiltration Upward motion of piston automatically refils barrel (Pitkin)

easily taken apart and sterilized, its light weight makes possible a delicate technic in handling, and the lock permits of firm attachment of the needle by a half turn at the hub For extensive infiltrations a continuous flow syringe, such as the Pitkin

type, is convenient and will save time, since the upward motion of the piston automatically refils the instrument (fig 193b)

(2) *Needles* Several needles of different lengths and gauges are necessary for local anesthesia, the choice being regulated by the nature of the structures through which they are to pass. For the raising of an anesthetic wheal a needle 1.5 cm long #22 gauge or 2.5 cm. long #24 gauge is employed, for subcutaneous injections one 5 cm. long #20 gauge is used, and for deeper injections one 10 cm. long #20 gauge Irrespective of the size of the needle, the point should have a long flat bevel, and should not be too sharp or too fine, otherwise, the feel of the various layers through which it passes is apt to be lost. While it is true that needles made of platinum iridium are flexible and retain their points, those of nickel plated steel serve as well. If steel needles are used, they should be tested and replaced frequently, in order to avoid breakage from rusting Since breakage usually takes place at the hub, all needles should be of sufficient length to permit the hub to remain well outside the tissues during the injection. In the event of such an accident the fragment will be more easily removed if a good-sized portion projects on the surface Old needles should be discarded, as they are prone to break. Furthermore, the oxidized material present in their lumina is difficult to remove and if introduced into the tissues may produce untoward reactions.

Sterilization of syringes and needles admits of no compromise. All parts of the syringe should be boiled for 5 minutes or autoclaved. Sterilization in alcohol and glycerin or other chemicals cannot be relied upon. Before use, the separate parts of the syringe should be rinsed in distilled water to remove all traces of alkalies, which are not only incompatible with the anesthetic agent, but when introduced into the tissues may set up a reaction. Immediately after use the syringe is disconnected, the parts passed through a 10 per cent formalin solution, rinsed in sterile water, dried, and wiped with instrument oil. The needles are treated in a similar manner and stylets are inserted into their lumina.

(3) *Solutions* Epinephrin solution should be kept in a brown-colored dropping bottle and should not be permitted to come in contact with alkalies, since both light and alkalies cause it to decompose. It is added to the procain solution just before use. Repeated boiling of procain solution tends to render it hypertonic and alter its pH content, and since these changes interfere with healing fresh solutions should be resorted to

Position of Patient. Whenever possible, the anesthetic is introduced with the patient in the recumbent position. The arms are secured to the side of the table or across the chest. A pad placed under the loin to maintain the normal lordosis will do much to alleviate postoperative backache. In the case of timorous individuals it is advisable that someone be in attendance at the head of the table, tactfully and unostentatiously lending moral support.

Introduction of Needle. Just before the introduction of the anesthetic agent the patient is told that a drop or two of "medicine" is going to be used to relieve all pain and is informed that the initial prick of the needle will feel like a mosquito bite. The pain of the needle prick will be minimized if a sharp needle is used and the solution introduced slowly and without pressure. It may even be entirely abolished by a preliminary application of some topical obtundent, such as a drop of cocain on a mucous membrane or a drop of phenol solution on the skin. After the first wheal has

been raised, a remark may be made, such as "That's fine; this is the most I'm going to hurt you" This will tend to reassure the patient that everything is in order The conversation previously started to distract his attention is now resumed During the interval before the anesthetic begins to act the patient is warned that peculiar sensations, rapid pulse, and sweating may be occasioned by the "medicine" and that he is not to become alarmed, since these symptoms are expected and will wear off in the course of a few minutes

Raising of Wheal The intradermal wheal is the basis of all local anesthesia. Through these insensitive areas all subsequent injections are made. In raising the

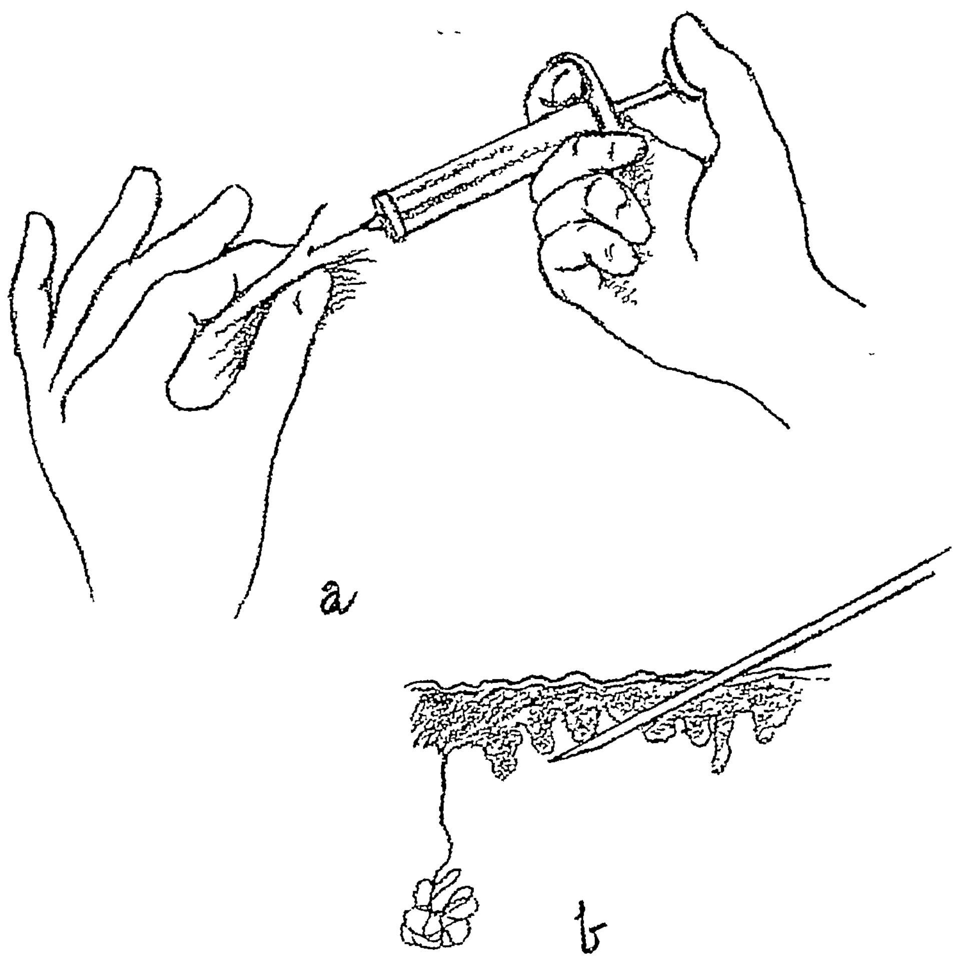

FIG 194 Raising of intradermal wheal *a*, skin pinched between left index finger and thumb, and needle introduced with tangential stab *b*, sectional view, showing bevel of needle pointing downward, and level to which it is passed

wheal every care should be taken to minimize trauma; otherwise, healing may be delayed The finest needle capable of introducing the anesthetic, preferably #24 gauge, should be used, and a fresh sterile needle employed for each injection. The syringe is grasped in the right hand, the bevel of the needle being directed downward against the skin which is pinched up between the left index finger and thumb (figs 194–195). The needle is introduced with a deliberate stab tangentially into the skin, to a depth just sufficient to bury a part of the bevel Pressure on the plunger is begun as soon as the instrument enters the skin, so that the moment the edge of the bevel is covered, the wheal will start to form Should the injection be delayed until the entire end of

the needle is buried unnecessary pain will be occasioned. The solution is introduced slowly, only enough pressure being exerted for its expulsion Almost immediately there will appear at the site of injection a pale elevated area, the surface of which is white and pitted like pigskin. Through this initial wheal, which will become insensitive almost at once, the deeper structures are infiltrated or the nerves blocked. Since the wheal remains visible for only a short while, it will be well to mark it with a colored solution.

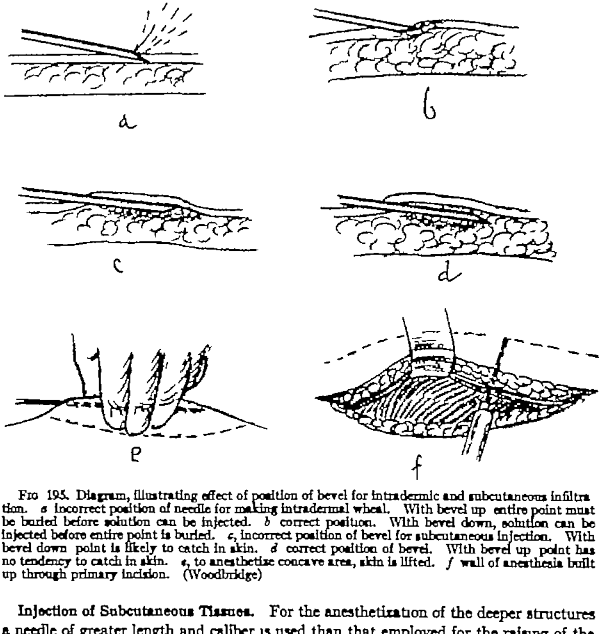

FIG 195. Diagram, illustrating effect of position of bevel for intradermic and subcutaneous infiltration. *a* incorrect position of needle for making intradermal wheal. With bevel up entire point must be buried before solution can be injected. *b* correct position. With bevel down, solution can be injected before entire point is buried. *c*, incorrect position of bevel for subcutaneous injection. With bevel down point is likely to catch in skin. *d* correct position of bevel. With bevel up point has no tendency to catch in skin. *e*, to anesthetize concave area, skin is lifted. *f* wall of anesthesia built up through primary incision. (Woodbridge)

Injection of Subcutaneous Tissues. For the anesthetization of the deeper structures a needle of greater length and caliber is used than that employed for the raising of the initial wheal. The needle is forced through the wheal into the tissues in a horizontal direction, and the solution is delivered either as the needle advances or as it is being withdrawn. In the former method the pressure of the solution preceding the needle tends to push aside the small vessels and thus lessens the danger of their being punctured. In the latter the needle is inserted to the limit of the area to be infiltrated, the piston is then slightly withdrawn, to make certain that the point has not pierced a

blood vessel, and the solution is delivered as the needle is being removed. While this method will cause a little more pain, it is safer. In either case the solution is introduced slowly, only enough pressure being exerted on the plunger to discharge the liquid. Too rapid a delivery inflicts unnecessary pain and irritation, especially in dense structures. After the injection of 1 or 2 cc., it is well to interrupt the procedure to note the patient's response to the anesthetic; should any untoward symptoms manifest themselves, the injection is discontinued until they disappear. During the injection of the deeper tissues care should be taken to prevent breakage of the needle; lateral movements are to be avoided, and the needle should not be sunk to the hub. When the contour of the body surface is such that it will not permit of the introduction of the instrument in the direction of the long axis of the syringe, an instrument with an eccentrically placed needle will facilitate the procedure. In order that no appreciable amount of the anesthetic agent may enter the circulation, the piston should be withdrawn from time to time to determine whether the needle is in a vessel. If blood appears, the needle is withdrawn and reinserted in another direction. Following deep tissue infiltration, an interval of 5 to 10 minutes must be allowed to elapse before operation, so that anesthesia may have time to become established. Insensibility is tested by noting the patient's response to a pin prick in the infiltrated area. During operation care should be taken not to transgress the limits of the field of anesthetization, and the tissues should be cut and not stretched, pulled, or torn, since these procedures cause pain by the drag they exert on unanesthetized structures.

Methods of Securing Local Anesthesia

Surface Application

Surface anesthesia is induced by applying the anesthetic agent to the skin, to mucous membranes, and to open wounds. It finds its greatest usefulness in cases of superficial operations in the oral and nasal cavities, the larynx, trachea, eye, and urethra. The principal drugs employed are ethyl chlorid, cocain, nupercain (percain), butesin, pantocain, and metycain.

Ethyl Chlorid. Ethyl chlorid is delivered in the form of a fine spray and produces superficial anesthesia by refrigeration of the tissues. The efficacy of cold as an anesthetic agent has long been recognized. Larrey, chief surgeon in Napoleon's army, relates that in 1807 during the winter campaign in Russia, with the temperature at 19° below zero, amputations were almost painless.

The applicability of ethyl chlorid is limited to short operations—for instance, to open a superficial abscess or to render the skin insensitive prior to the introduction of the needle for local anesthesia—and even in these procedures it has the undesirable effect of lowering tissue resistance and of being followed by pain as the tissues thaw. The inflammability of the liquid constitutes a further argument against its use.

Prior to its application the tissues to be anesthetized are dried and the adjacent parts covered with vaselin or gauze pads to provide for the absorption of any excess ethyl chlorid which may trickle away from the sprayed a[illegible] With the capillary end of the tube held 15 to 30 cm. away fr[illegible] part t[illegible]ized, the valve is completely opened, and the area is spra[illegible] and white. Freezing will

occur in $\frac{1}{2}$ to 3 minutes. Either the entire area to be incised may be thus frozen solid or a ring of frozen tissue may be made to encircle the site. The former method should be avoided when possible, as the extra pressure required for the incision of solidified tissue occasions unnecessary pain.

Cocain. Cocain is the only local anesthetic which also serves as a vasoconstrictor, but because of its toxicity and its short active period it has been superseded by agents which are less toxic and which induce a more lasting anesthesia. It finds its greatest usefulness in the desensitization of mucous membranes. For the conjunctiva a few drops of a 4 per cent solution are instilled into the eye with an eye-dropper in the nose it is used as a 10 per cent solution or a 5 per cent spray, in the mouth and epipharynx as a 5 per cent solution, and in the larynx and bronchi as a 10 to 20 per cent solution. In no event should the total amount of the drug exceed 0 09 gram ($1\frac{1}{2}$ grains)

Nupercain (Percain) is a colorless, tasteless, crystalline substance derived from quinolin. It is readily soluble in water and alcohol and may be repeatedly boiled with out danger of deterioration. It is decomposed by alkalies. Its action is powerful and prolonged, and therefore it must be used in extremely small doses. For the anesthetization of the mucous membrane of the nose and throat it is used in a 2 per cent solution, and for the urethral mucosa in a solution of 1 1000 concentration

Butesin. Butesin in a 2 per cent solution is an efficacious surface anesthetic. A small amount of a 5 to 10 per cent solution in the form of a spray is equivalent to a 10 to 20 per cent cocain spray It may also be used in the form of a dusting powder for the desensitization of painful denuded areas.

Direct Infiltration

Direct infiltration is a rapid and relatively painless form of anesthesia in which the anesthetic agent is injected directly into the line of incision, paralyzing the nerve endings at the site of operation. Nevertheless, the method has many objectionable fea tures. It lacks precision destroys anatomic orientation by producing a glossy edematous field, and has a tendency to lower the resistance of the tissues and predispose to infection

The technic is as follows A skin wheal is raised in the manner already described (p 412) at a point well beyond the limits of the proposed incision. The needle is then inserted into the border of the initial wheal and carried through the subcutaneous tissues parallel to the skin for a distance equal to about half the length of the needle. As the anesthetic agent enters the tissues, a definite ridge of skin will be raised which rapidly becomes insensitive. The needle is withdrawn and reinserted into the distal part of the ridge, and the process is repeated. In this manner an area of skin can be anesthetized in any direction and of any desired outline (fig 196) After anesthetiza tion the part is gently massaged for the dissemination of the solution. If the deeper layers are to be incised, they must also be infiltrated, and one of two methods may be used (1) Following the skin injection, a long needle is introduced vertically into the anesthetized skin, and forced gently into the deeper structures. Several such injec tions are made the number depending upon the extent of the area to be desensitized (2) After the initial skin incision the deeper structures may be infiltrated layer by layer in the same manner as the superficial area.

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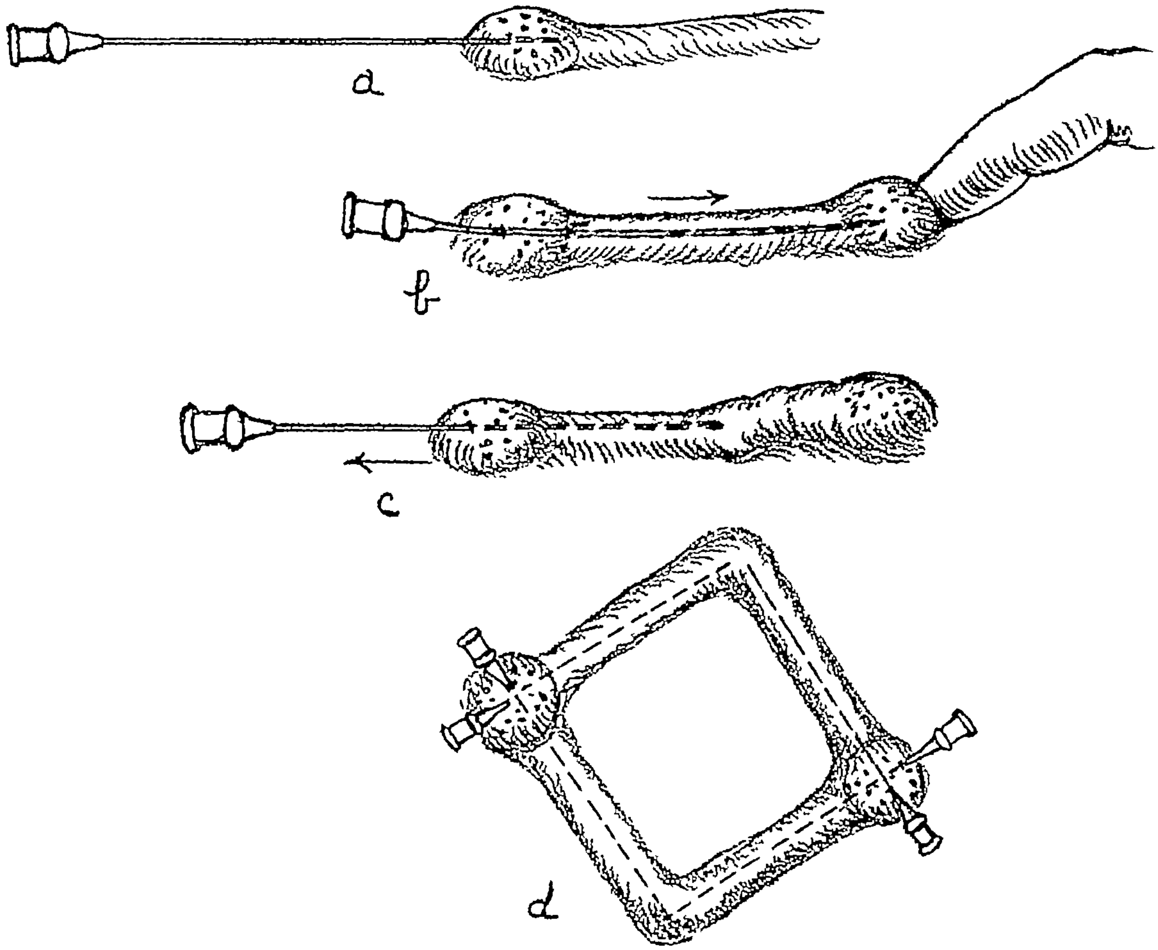


FIG 196 Anesthetization by direct infiltration *a*, wheal raised *b*, secondary wheal raised subcutaneously by advancing needle and depressing skin to bring it into proper plane *c*, skin infiltrated as needle recedes (Farr) *d*, quadrilateral area anesthetized by introduction of needle through two previously raised wheals

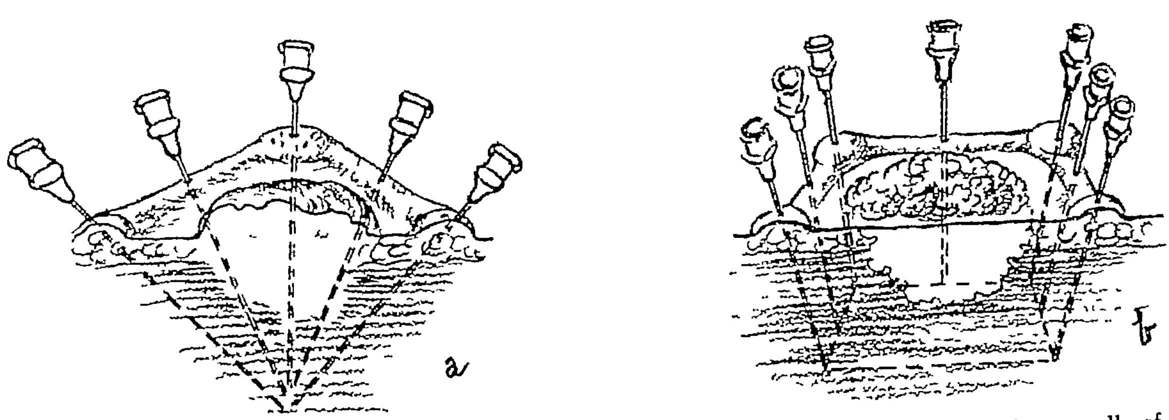


FIG 197 Anesthetization by indirect infiltration Operative site isolated by *a* oblique walls of anesthesia meeting *below*, and *b* perpendicular walls raised *around* area

Indirect Infiltration

Indirect infiltration (field block, circular block) consists in isolating the proposed operative site by raising walls of anesthesia at some convenient situation at a distance from the field of operation This method has superseded direct infiltration, because

it eliminates the inconvenience of working in an edematous, distorted area, lessens the danger of infection and interference with healing, and minimizes the tendency to postoperative oozing. However, this form of anesthesia is necessarily limited to surgery in which the extent of the pathologic lesion is definitely known. It is especially applicable to the removal of small neoplasms and to the circumvallation of infected and inflamed fields of operation.

Indirect infiltration is accomplished either by the erection of perpendicular walls of anesthesia *around* the operative site, or of oblique walls *meeting below* the area. In either case the operative area is first encircled by a series of intradermal wheals 5 to 10 cm. apart. A larger needle is then inserted into each of the original wheals and carried down vertically or diagonally to the limits of the operative depth. Within 10 minutes the enclosed area is insensitive (fig. 197).

Nerve Block

Nerve block (conduction or block anesthesia) is a form of anesthesia brought about (1) by the injection of the solution directly into the nerve supplying the field of operation (endoneural block), or (2) by the introduction of the solution into the tissues lying in close proximity to the nerve, the agent being absorbed into the nerve substance through the perineurium (perineural block) (fig. 192). Examples of the latter type are spinal anesthesia and splanchnic nerve blocks. Nerve block is the ideal method of isolating the field of operation from its sensory nerve supply. A minimal quantity of the drug induces a prolonged analgesia, one or two injections are sufficient for the desensitization of a large area, and if proper precautions are taken to relax the nerve, pain will be slight. The objection that this procedure may cause degeneration of the nerve fibers is theoretical, since clinically permanent paralysis following such injections is exceedingly rare.

The desired point of injection is determined by definite bony landmarks. After the initial wheal has been raised, an unmounted needle is introduced into the tissues in the direction of the long axis of the nerve and carried to the requisite depth. That the needle is in the correct position will be indicated by a sudden sharp pain in the area supplied by the nerve. Without disturbing the needle, the syringe is attached. If the operative site is in the vicinity of a large vessel the piston is slowly withdrawn, and if blood appears in the cylinder, the needle is removed and reinserted in another direction. The amount and concentration of the solution to be injected will depend upon the size of the nerve. Ordinarily 2 to 5 cc. of a 2 per cent solution of procain epinephrin will be sufficient.

The technic of blocking individual nerves will be described in the appropriate sections.

Spinal Anesthesia

Spinal anesthesia is a form of local anesthesia in which insensibility of the nerve roots is brought about by an injection of the agent into the spinal subarachnoid space. The method was first advocated by Corning (22) in 1895 and was employed clinically one year later by Bier (11) who used cocain for the purpose. But it did not come into general use until 1906 when Barker (8) perfected the technic and resorted to the less

toxic stovain When employed by an experienced anesthetist it has a definite value in selected cases The anesthetic mortality is difficult to estimate, since the majority of available statistics fail to indicate whether death was caused by the drug, the disease, or the operation itself Lehman, Risher, and Bippus (56) found in a series of 3,539 cases that the anesthetic mortality rate following spinal anesthesia was 0 028 per cent.

Following the introduction of an anesthetic agent into the subarachnoid space of the spinal cord, there result in the area below the injected segment the following consecutive phenomena (1) increase in skin temperature, attributed to the paralyzing effect of the solution on the sympathetic vasoconstrictor fibers, (2) loss of temperature and pain sensation, (3) motor paralysis, (4) abolition of joint, pressure, and touch sensations, (5) fall in blood pressure—in low block, probably due to paralysis of the rami communicantes, and in high block, to paralysis of the cardiac accelerator fibers, (6) the respiratory excursions are diminished, due to involvement of the intercostal nerves, with a consequent interference with oxygenation of the tissues Should the paralysis be allowed to rise to the level of the phrenic nerve, death results from a failure of the diaphragm (51)

Indications The scope of spinal anesthesia is limited principally to operations below the diaphragm (77) wherein general anesthesia is deemed unsafe and other methods of local desensitization are likely to be inadequate It offers the advantage of complete muscular relaxation, which makes it valuable in operations on the abdomen, pelvis, and lower extremities, especially in the case of muscular and obese patients Because only a small quantity of the drug is necessary to bring about anesthesia, its toxic action is comparatively low, rendering its use desirable for operations in the presence of obstructive jaundice, kidney, respiratory, and circulatory disorders, such as hypertension and congestive cardiac disease Moreover, since it has little effect on blood-sugar, it can be employed to advantage in diabetic patients The relative absence of postoperative nausea and vomiting makes it desirable for operations on the intestines It is also of diagnostic value in vasospastic diseases In a suspected case, a failure of the surface temperature to rise following the paralytic action of the spinal anesthetic on the vasoconstrictor nerves would indicate that the spasm is not an arterial one, and that therefore a sympathectomy would be of no benefit

Contraindications The principal objections to spinal anesthesia are the following It causes a drop in blood pressure and is therefore contraindicated in patients whose blood pressure is already low—for example, those suffering from debility, shock, hemorrhage, or hypotension It should also be avoided in the presence of anemia and diminished pulmonary capacity, as in these instances the subsequent fall in pressure may bring about a serious anoxemia Its duration is comparatively short, the effect lasting on an average of 50 minutes, and hence its use for prolonged operations is prohibited Furthermore, individual tolerance is so variable that it is difficult to gauge the dose Matas points out that the very fact that various types of vasostimulants must still be administered simultaneously with the spinal injection is the best proof that bulbar paresis and arterial hypotension are unpredictable potential dangers There is also a risk of infection of the cerebrospinal fluid, especially if the area through which the hypodermic needle passes is septic The toxic action of the solution and the trauma occasioned by the lumbar puncture may bring about postoperatively such complications as headache, vomiting, diplopia, pyrexia, pain in the legs, paresis, anesthesia,

and trophic changes in the lumbar region. These manifestations, however, are usually of short duration. Spinal analgesia is generally inapplicable in the case of children, because of their lack of co-operation, in operations where a considerable loss of blood is expected (18), and in neurologic conditions, such as tabes dorsalis and intracranial hemorrhage

Administration. Spinal anesthesia demands a careful choice of the anesthetic agent and constant observation of the patient throughout the entire period of desensitization. In the absence of a qualified anesthetist, it had best not be undertaken. The level of anesthesia will depend upon a combination of the following factors the position of the patient, the specific gravity, volume, and rate of injection of the solution, and the site of its introduction.

The position of the patient and the specific gravity of the solution will influence the level of anesthesia mechanically For example, with the patient in the dorsal position a solution heavier than spinal fluid will gravitate along the plane of the dorsal roots and cause a greater degree of posterior or sensory anesthesia than of motor, conversely, a solution of lighter specific gravity, with the patient in the same position, will tend to diffuse along the anterior roots and cause a greater degree of motor paralysis than of sensory

Hyperbaric solutions—*i.e., those with a specific gravity above 1 010*—produce anesthesia by virtue of gravitational diffusion. Therefore, in order to obtain the desired level of anesthesia with these solutions, the patient is placed in varying degrees of the Trendelenburg position, so that the nerve roots that supply the upper limits of the area to be anesthetized may be made the most dependent part of the spine, the force of gravity carrying the solution to the required level. Although the Trendelenburg position is of advantage in the maintenance of the blood pressure, it incurs the danger that the hyperbaric solution may be carried beyond safe limits, and to overcome this objection the use of hypobaric solutions has been suggested. In view of the fact that these solutions can be given in larger quantities, the desired level of anesthesia will be obtained not so much by gravitational diffusion, as by an increase or decrease in the volume of fluid introduced. Jones (52) advocates a 1 1500 percain in 0.5 per cent saline solution, with a specific gravity of 1 003

Kirschner (53) attempts to regulate the level of spinal analgesia by displacing a part of the spinal fluid by a given volume of air (fig 198) With the patient in a 25 degree Trendelenburg position, a lumbar puncture is made, a given quantity of cerebrospinal fluid is withdrawn and a measured volume of air is introduced. Following the introduction of the air a 0.25 per cent percain solution combined *with glucose and having* a specific gravity of 0 987 is injected. Since the solution cannot extend past the air bubble below and is non-miscible with the cerebrospinal fluid above, only a small girdle of the spinal nerves will be anesthetized. By an increase or decrease in the quantity of injected air the desired anesthetic level is obtained (84)

The technic is as follows For *high abdominal anesthesia*, the puncture is made between the twelfth dorsal and first lumbar vertebrae, and 30 cc. of cerebrospinal fluid are withdrawn. Three cc. of air are then injected and 1.5 cc. of the solution delivered through a needle with its bevel turned upward. This is followed by a second injection of 2 or 3 cc. of air In 5 minutes the skin is tested for the degree and extent of desensitization. If the anesthesia is insufficient, another 0.5 cc. of the solution is injected,

if the anesthetic zone is too low, 2 or 3 cc more of air are introduced. For *low abdominal anesthesia* the puncture is made between the first and second lumbar vertebrae, 20 cc of cerebrospinal fluid being removed, and for *leg anesthesia* the puncture is made between the second and third lumbar vertebrae, 10 cc of fluid being withdrawn The dose of the 0 25 per cent solution of percain ranges from 1 5 to 4 cc and averages 2 cc

Hewer (48) states that " there are several obvious disadvantages to this procedure For example, even a momentary alteration in the steep Trendelenburg position might have disastrous consequences Again, it seems doubtful whether it is

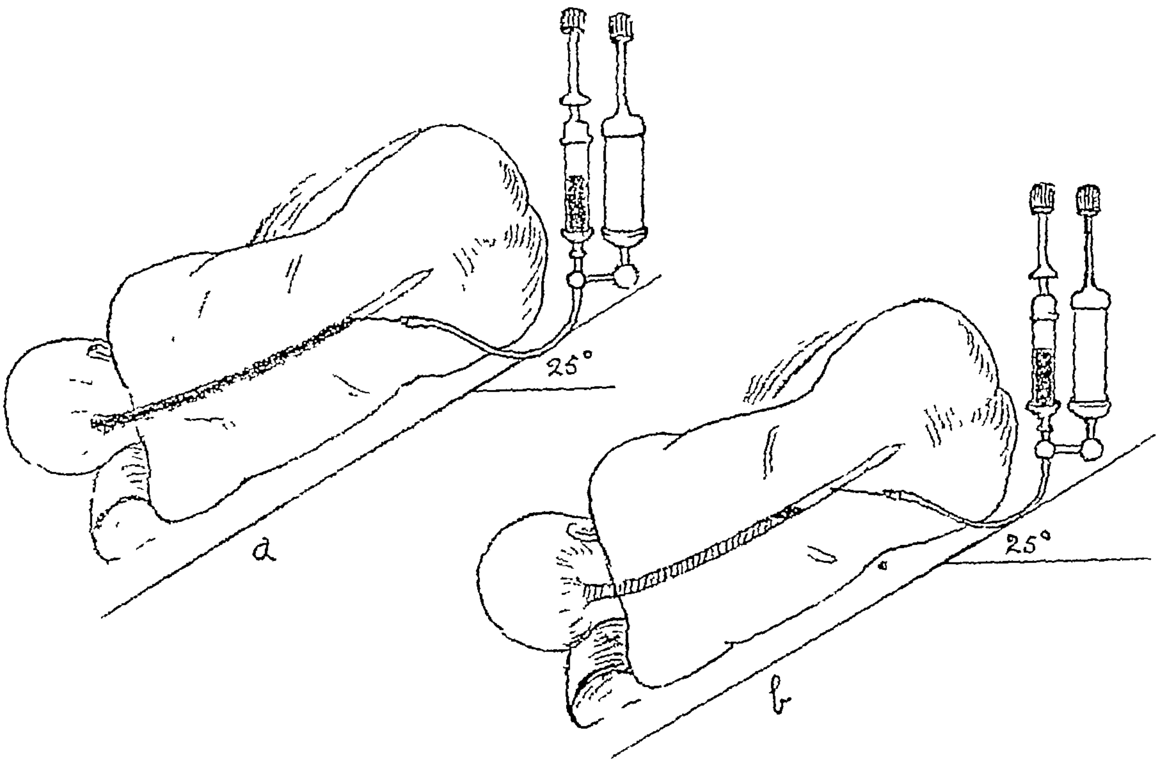


FIG 198 Kirschner's method of regulating level of spinal anesthesia with air *a*, pelvis tilted to angle of 25 degrees Double syringe connected with spinal needle by rubber tube provided with glass tube, so that passage of air or fluid can be observed Large cylinder used for aspiration of cerebrospinal fluid and injection of air into dural sac Small cylinder filled with *percain solution* (0 25 per cent) in glucose, with specific gravity of 0 987 Outlets controlled by stopcocks Caudal portion of dural sac filled with air Liquor level corresponds with point of entrance of needle *b*, *anesthetic charge ejected* cranialward Only small girdle of spinal nerves is anesthetized, since solution cannot extend past air bubble below and is non-miscible with cerebrospinal fluid above Anesthetic charge forced to desired level by additional injections of air

wise to deprive the lower part of the spinal cord and the cauda equina from their normal protection of cerebro-spinal fluid "

(1) *Preparation* The preparation for spinal anesthesia is essentially the same as that for any form of local desensitization Nervous patients require heavy preanesthetic medication A tranquil night's rest may be assured by the oral administration of pentobarbital sodium (nembutal) in 0 1 to 0 2-gram (1 5- to 3-grain) doses One hour before operation the same dose is repeated, followed by a hypodermic injection of morphin 0 01 to 0 016 gram ($\frac{1}{6}$ to $\frac{1}{4}$ grain) If the spinal analgesia is to be supplemented with inhalation anesthesia, atropin 0 0004 gram ($\frac{1}{150}$ grain), is also given If for any reason preanesthetic medication is contraindicated, the patient may be

placed in a state of light general anesthesia by means of small quantities of gas-oxygen or cyclopropane the administration of which may, if necessary, be continued throughout the operation As a precaution against a critical drop in blood pressure, ephedrin sulphate is administered prior to anesthesia (82) In the case of patients whose blood pressure is normal, 0 025 gram (⅜ grain) is injected intramuscularly 10 minutes before the introduction of the anesthetic. If the blood pressure is abnormally low, the dose is doubled, if abnormally high, it is decreased and the injection delayed until after the anesthetic has been administered. A subsequent drop in blood pressure calls for an additional 0 025 gram (⅜ grain), but under no circumstances should the total dose exceed 0 075 gram (1⅛ grains)

(2) *Choice of Anesthetic Agent and Dosage* All types of local anesthetics, both singly and in combination, have at one time or another been experimented with for use in spinal anesthesia. Procain seems to be the safest, although it induces but a short period of anesthesia, lasting between 30 and 90 minutes. For operations requiring 1 or 2 hours, pantocain is resorted to, and for longer periods, nupercain (percain) The dose will depend upon the patient's age, weight, blood pressure and hemoglobin percentage, and upon the site and duration of the operation. If procain is to be employed, the average dose is 0 001 gram to 0 0015 gram per pound of body weight in a 1 per cent solution. The maximum dose for an adult of average size is 0.20 gram (3⅛ grains), with a maximum concentration of 4 to 5 per cent (66) Pantocain may be added to the procain to prolong the anesthesia, in which case 0 01 gram of pantocain and 0 1 gram of procain will usually be sufficient to carry the desensitization as high as the fifth or sixth rib

(3) *Position of Patient* Spinal anesthesia may be induced with the patient in the sitting or in the recumbent position. For low blocks the sitting position is preferable The patient is placed on the edge of the operating table with his legs hanging over the side, his spine flexed, and his arms hanging freely between the legs. If the recumbent position is chosen, he is placed on his left side, his spine is flexed so that his knees and chin will approximate each other, and his pelvis is slightly elevated by means of a flat pillow placed beneath the hip (fig 199)

(4) *Introduction of Anesthetic Agent* The patient's back is sterilized with green soap and water and mopped with alcohol and ether No other chemical is used, lest an irritating substance be carried into the spinal canal. The area selected for lumbar puncture is then anesthetized as follows A skin wheal is raised in the usual manner and the subcutaneous tissues infiltrated with 2 cc. of a 1 per cent procain solution (p 413) The choice of the site for spinal puncture will depend upon the level of anesthesia desired. For operations in the upper part of the abdomen the space between the first and second lumbar vertebrae is selected, for the middle part of the abdomen, the area between the second and third lumbar vertebrae and for operations on the thigh perineum, urethra, groin bladder, or anus, the space between the third and fourth lumbar vertebrae. A line drawn just above the highest points of the crests of the ilia will bisect the fourth lumbar spinous process and serve as a convenient landmark. A lumbar puncture is then made in the usual manner (p 543) by means of a #21 gauge gold spinal needle 9 cm. long with a 45 degree bevel. As soon as the spinal fluid begins to flow a 10 cc. syringe is attached to the needle and sufficient liquid is withdrawn to dissolve the anesthetic agent 2 to 4 cc. being as a rule sufficient. The

needle is then sealed with its stylet If a hypobaric solution is to be used, no spinal fluid need be removed

The anesthetic solution is injected slowly through the spinal needle originally introduced, a constant speed of 0 5 cc per second being maintained Following the injection the spinal needle is withdrawn and a small sterile dressing applied to the puncture site If the injection was made with the patient on his side, he is rolled over on his back, so that the anesthetic may be diffused along the dorsal root Desensitization will occur in from 5 to 10 minutes following the injection, at which time the patient is placed in the Trendelenburg position, an 8-degree inclination being maintained for full abdominal anesthesia, and a 5-degree inclination for low abdominal anesthesia At the same time the head and neck are raised, so that the anesthetic will not be carried by gravity to a height which would endanger the phrenic nerve The level of anesthesia is tested by noting the patient's reaction when the skin over the

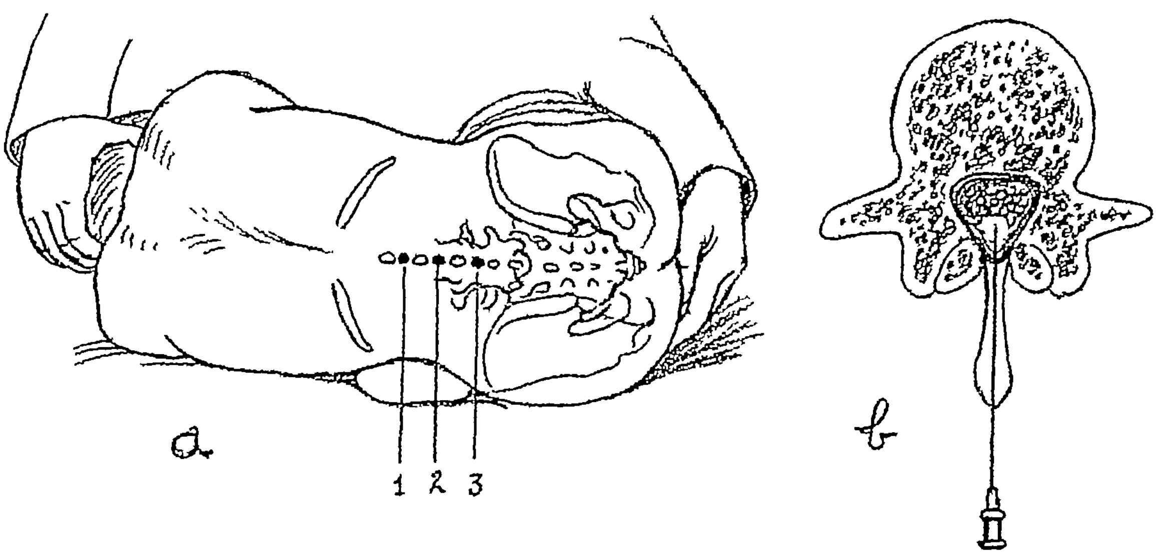


FIG 199 Spinal anesthesia *a*, position of patient *1*, needle introduced into space between first and second lumbar vertebrae, for upper abdominal operations *2*, space between second and third lumbar vertebrae, for lower abdominal operations *3*, space between third and fourth lumbar vertebrae, for operations on perineum and lower extremities *b*, sectional view, showing needle in place in spinal canal

area is pricked If desensitization is imperfect, it is reinforced by some form of inhalation anesthesia

(5) *Maintenance of Anesthesia* During anesthesia the blood pressure, pulse, and respiration are recorded at 5-minute intervals If the blood pressure falls to 15 to 20 points below the original reading, the angle of inclination of the Trendelenburg position is increased, and 3 to 5 minims of 1.1000 epinephrin are injected intramuscularly or intravenously, the dose being repeated in 10 minutes if necessary Should symptoms of respiratory depression develop, inhalations of 10 per cent carbon dioxid in oxygen are administered If anesthesia wears off before the operation is completed, it is supplemented at the first sign of discomfort by inhalation anesthesia, cyclopropane being the agent of choice, as it insures quick induction and can be administered with a high oxygen content

(6) *After-Care* As soon as the operation is completed, the patient is put to bed with his head low until the blood pressure has returned to approximately the normal

level He is furnished with a perineal pad until the sphincter reflexes reappear The blood pressure is recorded every 15 minutes for 4 hours, or until it reaches a normal level. If heat is to be applied, care must be taken not to burn the patient, as skin sensations remain blunted for some time. If the patient complains of headache or pain an ice bag is applied over the part, or morphin 0 01 gram (⅙ grain) or pantopon 0 02 gram (⅓ grain) is administered every 4 hours if necessary

GENERAL ANESTHESIA

Non Inhalation Anesthesia

Non inhalation anesthesia is induced by the administration of the anesthetic agent either intravenously or rectally

Intravenous Anesthesia

Intravenous anesthesia is used for short operations requiring muscular relaxation and in cases where for some reason inhalation is contraindicated—for example, in patients suffering from respiratory diseases. This method induces a quick and pleasant anesthesia followed by prompt recovery accompanied by a minimum of nausea and vomiting

A variety of drugs have been experimented with for this purpose, but only a limited number have met with any degree of success. Among these are certain of the rapidly acting barbiturates. Evipan sodium and pentothal sodium have been found to be the safest, but unfortunately their effect is transitory, the duration seldom exceeding 10 to 15 minutes. For a more sustained effect pentobarbital sodium (nembutal) must be resorted to, but its use is associated with considerable danger Inasmuch as the barbiturates are detoxified in the liver and are excreted by the kidney, their introduction is contraindicated in the presence of hepatic and renal impairment, and *because of their depressive action on the circulation, they are best avoided in cardiovascular* diseases and in hypotensive states.

Evipan Sodium (*Evipal*) was the first barbiturate to prove satisfactory for intravenous anesthesia, and it still remains the agent of choice. It has no cumulative effect, being rapidly destroyed by the liver and excreted by the kidney, and the margin of safety between the anesthetic and the toxic dose is wide. It has little effect on blood-sugar and causes a lesser degree of respiratory depression than do other barbiturates. Should it be inadvertently injected outside of the vein, it causes only slight local reaction. As has been said above, its principal objection is the brevity of the anesthesia.

Evipan sodium and the distilled water for its solution are marketed in separate glass ampules, one containing 1 gram of the powder, and the other 10 cc. of sterile water Ten minutes before use the contents of both ampules are thoroughly mixed and drawn up in a 20 cc. Record syringe, thus making a 10 per cent solution. The dose necessary to secure surgical anesthesia usually ranges between 10 and 13 cc. but *under no circumstances* should it exceed 25 cc.

The action of *pentothal sodium* resembles that of evipan, but it is 30 to 50 per cent more potent therefore its effect is more rapid, more profound, and more depressing to the respiratory tract. On the other hand, it does not act directly on the heart

hence its influence on the blood pressure is less marked If the solution is injected outside of a vein, it causes a greater local reaction than does evipan and may lead to inflammation and ulceration Like evipan, it is marketed in double ampules, one containing 1 gram of the powder, and the other, 10 cc of sterile water

Pentobarbital Sodium (*Nembutal*) is marketed in double ampules, one containing 0.5 gram of the powder and the other, 10 cc of sterile water, the mixture forming a 5 per cent solution The average quantity required to bring about anesthesia is 5 to 6 cc In no event should the dose exceed 8 cc

Administration Inasmuch as patients recovering from intravenous anesthesia are likely to display considerable restlessness, it has been suggested that morphin 0 01 gram ($\frac{1}{6}$ grain) and scopolamin 0 0004 gram ($\frac{1}{160}$ grain) be administered hypodermically prior to anesthesia, but in view of the depressing effect of the barbiturates on the respiratory system, it would seem that such premedication had probably best be omitted

Because of the short duration of intravenous anesthesia, all aseptic preoperative preparation should be completed before its induction The patient is placed in the desired position for operation before the introduction of the needle, since any subsequent change of posture may dislodge the instrument

The necessary *armamentarium* consists of a 20 cc Record syringe, several sharp, short, beveled intravenous needles, #17 to #20 gauge, about 3 cm long, a blood pressure cuff, a mouth gag, small surgical dressings, ampules of the anesthetic agent, sterile water, and a file to open the ampule.

The *median basilic vein* is usually the most convenient for intravenous induction, although any vein that appears to afford easy entry may be chosen The vein is rendered prominent by means of a blood pressure cuff (p 364), and the needle is introduced A drop or two of blood is aspirated to make certain that the needle is actually in the vessel, whereupon the constricting band is released, and the injection begun, about 15 seconds being consumed in the delivery of 2 or 3 cc of the solution A "safety pause" is then allowed, in order that the patient's reaction to the drug may be observed The next 3 or 4 cc are introduced over a period of 30 seconds, after which another "safety pause" is made If the patient's condition is satisfactory, the remainder of the dose is administered Anesthesia begins in 15 to 30 seconds, being manifested by a slurring of the speech, shallow respiration, yawning, contraction of the pupils, and possibly slight tremors During the induction care must be taken to maintain a free airway Owing to the muscular relaxation, the tongue may fall back into the pharynx, and to prevent this accident a mouth gag should be inserted If the respirations become depressed, 10 per cent of carbon dioxid in oxygen is administered under slight pressure in a closed bag, and 5 cc of coramin are introduced hypodermically or 3 cc intravenously An undue fall in blood pressure is prevented by administering the anesthetic agent with the patient in the recumbent position Toxicity can be reduced to a minimum by a slow delivery of the solution and proper observance of "safety pauses" during the procedure

Rectal Anesthesia

Rectal anesthesia from the patient's standpoint is the most pleasant method of induction The anesthetic may be introduced surreptitiously in the guise of an enema,

the patient falling asleep and not waking up until several hours after the operation The agents most commonly employed are ether-oil, paraldehyd, and avertin, of which the latter is preferred and ranks in safety between ether and chloroform. The chief objection to the induction of anesthesia by means of rectal medication is the inability to control its level accurately, and for this reason the method can be used only (1) for a very light plane of anesthesia, (2) as a preliminary reinforcement to some other anesthetic agent and (3) as a basal narcotic.

The methods of administering *avertin* and *paraldehyd* have already been discussed in the section dealing with preanesthetic medication *Ether-oil* as a rectal anesthetic has been largely replaced by the former agents. When used, a cathartic, such as castor oil, is given the night preceding operation, followed in the morning by a series of warm water enemas at 1 hour intervals until the return is clear Usually 2 to 3 enemas will suffice. One hour before the administration of the anesthetic 2 to 4 drams of paraldehyd mixed with an equal quantity of olive oil are introduced slowly into the rectum through a tube inserted 4 inches beyond the sphincter A half hour later a hypodermic injection of morphin 0 01 gram ($\frac{1}{6}$ grain) and atropin 0 0004 gram ($\frac{1}{150}$ grain) is given. The anesthetic mixture consisting of ether 30 cc. and olive oil 90 cc. for each 75 pounds of body weight, is delivered slowly through the rectal tube. Not more than 8 ounces should be administered. Anesthesia begins in 10 to 20 minutes and lasts $2\frac{1}{2}$ to 3 hours. After operation the residue is siphoned off and 60 to 120 cc. of olive oil are run into the rectum.

Inhalation Anesthesia

Agents Employed

The anesthetic agents employed for inhalation anesthesia, in the order of safety are (1) nitrous oxid (N_2O) (2) ethylene, (3) cyclopropane, (4) ethyl chlorid (5) vinyl ether (vinethene) (6) diethyl ether (ether), and (7) chloroform. The ability of these agents to produce muscular relaxation is in inverse order to their safety Thus nitrous oxid, the safest anesthetic, produces the least amount of muscular relaxation, whereas chloroform, the most toxic, insures the greatest amount. With the exception of nitrous oxid and chloroform these agents are all inflammable

The gaseous anesthetics—namely nitrous oxid, ethylene, and cyclopropane—are safer than the liquid agents, inasmuch as their dosage can be controlled more accurately They induce rapid anesthesia with a quick recovery because of their low solubility coefficient in the blood. According to Barbour (7) "Narcosis is inversely proportional to solubility in the blood and 'inert tissues because greater solubility diverts more anesthetic substance from its seat of action." He attributes the rapid recovery to "first, the rapid excretion, not much anesthetic being stored in the blood and tissues because the solubility coefficient is low Furthermore the gas narcotics do not interfere with the efficiency of the circulation or the depth of the respiration they find better transport facilities for their excretion than do narcotics which impede their own elimination by depressing respiration circulation or both."

Nitrous Oxid (N_2O) Nitrous oxid is an inert non-inflammable gas and the safest of all the inhalation anesthetics In a reported series of 300 000 administrations there was not a single fatality and in another series of 1,161 820 only 2 deaths occurred. This

gas induces a rapid, pleasant anesthesia, with no demonstrable toxic effect on the lung, kidney, or liver, and insures rapid recovery without disagreeable symptoms The mechanism by which it induces anesthesia is not clearly understood Some attribute its action to a partial anoxemia, while others believe that it has a direct physiologic influence on the nerve cells Its anesthetic effects are observable in 3 stages: The first stage lasts from 20 to 30 seconds and is characterized by an increase in the respiratory rate, a rise in blood pressure, and a sensation of exhilaration The second stage is evidenced by incoherence of thought, purposeless muscular movements, twitching of the eyelids, and loss of consciousness The skin appears dusky, and the pulse is rapid and full. The third stage appears in 1 to 4 minutes and is that of surgical anesthesia Breathing is regular, the pulse is full, and the pulse rate slightly increased In many patients this stage can be maintained only if the quantity of nitrous oxid administered is raised to 90 per cent, and in such instances a variation of even 1 per cent in either direction may spell the difference between anoxemia on the one hand and insufficient anesthetization on the other Obviously, with such a concentration respiratory functions must be carried out with only 10 per cent of oxygen, an amount much less than that present in atmospheric air It is this high concentration with its risk of anoxemia which constitutes the principal objection to the use of nitrous oxid, although the danger can be somewhat reduced by heavy preanesthetic medication which will permit of the use of a greater percentage of oxygen The predominating symptom following an overdose of nitrous oxid is asphyxia, marked first by hyperpnea and then by dyspnea, cyanosis, dilatation of the pupils, impalpable pulse, cessation of respirations, and possibly death

The chief disadvantage of nitrous oxid is its inability to produce muscular relaxation This renders it inapplicable to abdominal surgery and other operations requiring relaxation Moreover, its tendency to produce anoxemia contraindicates its use in conditions characterized by obstruction or diminution in the size of the airways The muscular spasm it induces raises the blood pressure, therefore, it is interdicted in the case of patients suffering from cardiovascular diseases, especially those associated with hypertension Furthermore, the passive congestion consequent upon its administration predisposes to postoperative capillary oozing In recent years its field of usefulness has been encroached upon by the development of local anesthesia, but it still finds application in short operative procedures in which relaxation is not essential—such as the opening of abscesses, the extraction of teeth, or the removal of superficial tumors—in the aged, and those afflicted with hypotensive diseases

Nitrous oxid is administered by the closed method (p 432), and there are many machines on the market equipped with devices for the regulation of the exact percentage of nitrous oxid and of oxygen Prior to its administration the stomach should be empty and the mouth cleared of all foreign bodies The face piece is applied with the air valve open, pure nitrous oxid gas is turned on, and the patient is instructed to breathe deeply Oxygen is then added gradually, the amount used being guided largely by the color of the patient's skin After the withdrawal of the anesthetic agent, consciousness returns in 3 to 5 minutes

Ethylene. Ethylene is an unsaturated hydrocarbon gas, inflammable in the pure state and explosive when mixed with other gases It is slightly lighter than air and has an offensive odor resembling that of garlic It was introduced by Luckhardt and Carter (58) at the Presbyterian Hospital in Chicago in 1923 as a substitute for nitrous

oxid. Like the latter agent, it causes no impairment of the liver, kidney, or respiratory system, provided it is mixed with an adequate supply of oxygen. It has the advantage over nitrous oxid in that it is more potent, therefore, less time is required for induction, and it can be used in smaller concentrations, anesthesia being achieved with 20 per cent of oxygen. Moreover, it produces slightly better muscular relaxation On the other hand, the gas is not eliminated as rapidly as is nitrous oxid and the margin of safety is accordingly narrower The tendency toward postanesthetic nausea and vomiting is greater than that following nitrous oxid but less than that following ether Ethylene is administered in essentially the same manner and with the same apparatus as nitrous oxid.

Cyclopropane Cyclopropane is a colorless inflammable gas heavier than air and characterized by a pungent odor resembling that of ethylene. It is soluble in lipoids but insoluble in water To Henderson and Lucas (45), and Waters and Schmidt (122) belongs the credit for its introduction as an anesthetic. It has a low toxicity with a wide margin of safety, and does not produce anoxemia. Anesthesia can be secured with only 10 to 20 per cent of the gas. It has been aptly stated that in the case of nitrous oxid and ethylene inhalation the gases are administered with enough oxygen to keep the patient alive, while in cyclopropane inhalation, oxygen is administered with just enough gas to keep the patient asleep Cyclopropane seems to increase the tendency to capillary oozing during operation, although there is no alteration in the coagulation time of the blood. Recovery is rapid and unassociated with excitement and there is a minimum of postoperative nausea, vomiting distension, and general discomfort. The induction is rapid and pleasant, consciousness being lost without any feeling of suffocation. The gas is non irritating to the liver and kidney, causes only slight disturbance of metabolism, and does not materially alter the acid base equilibrium, unless used in high concentration. It has no specific effect on the heart or blood pressure except when administered in strong concentration, in which case it tends to invoke cardiac arhythmia, extrasystoles, and a fall in blood pressure. It is claimed, however, that these effects can be partly obviated by a preoperative administration of atropin.

Because the solubility coefficient of cyclopropane in the blood is less than twice that of nitrous oxid, the induction of anesthesia with the former agent is slower than that with the latter Cyclopropane is not a respiratory stimulant, nor does it increase bronchial secretions. Great care must be taken in its administration, inasmuch as the color of the skin is no index to the patient's condition. In view of the high percentage of oxygen with which the drug is administered, he may be in a danger zone and still retain a normal color This gas is more powerful than ethylene, produces greater relaxation, permits of a higher concentration of oxygen, occasions less postoperative nausea and vomiting and is less likely to explode Its potency is comparable to that of ether and chloroform, but it lacks the toxicity of the latter and its depressing effect on the circulation. The anesthetic state it creates is similar to that induced by ether but respirations are not stimulated, relaxation is not so complete, and postoperative bleeding and oozing are more frequent sequelae.

Because of its potency, cyclopropane can be administered with 50 to 85 per cent of oxygen, and thus is advantageous in patients suffering from anemia or cardiac and pulmonary disease. In anemia the value of a high oxygen supply is obvious. In cardiac disease the quiet breathing and the minimal effect of cyclopropane on the blood

pressure compensates for its possible depressing influence on the heart It is also useful in chest surgery, because of the shallow respiratory excursions and the rapid recovery of the cough reflex

Cyclopropane, because of its high cost, inflammability, and explosiveness when mixed with other gases or when used in the vicinity of an open flame, must be administered by the closed carbon dioxid absorption method (p 432) The gas machine must be equipped with reliable valves and indicators, so that the amount of gas may be accurately controlled, since an error in technic in the administration of this agent entails graver consequences than in the case of nitrous oxid or ethylene If preanesthetic sedatives are used, they should be given in comparatively small doses, inasmuch as cyclopropane, unlike other inhalation agents, is not a respiratory stimulant and therefore fails to compensate for the respiratory depression which these sedatives occasion Amiot (3) starts the anesthesia with 3000 cc of oxygen and 1000 cc of cyclopropane and corrects the proportion by observing the patient's reaction, increasing or decreasing the concentration as needed When the proper ratio has been obtained, very little additional gas is required for the maintenance of anesthesia The depth, rate, and rhythm of the respirations are an important index to the patient's general condition, too deep anesthesia being characterized by a fall in the rate and a diminution in the amplitude Waters states that cardiac arhythmia is one of the most valuable signs to indicate that the limit of tolerance has been reached

Ethyl Chlorid Ethyl chlorid as a general anesthetic is safe, convenient, and economical Its chief indication is for short operations in children It ranks in efficiency and toxicity between ether and chloroform, its anesthetic action being more rapid and more powerful than ether, and its toxic effect on the cardiovascular system and liver less pronounced than that of chloroform According to statistics, the average mortality rate may be considered about 1 in 13,000 In one reported series of 123,000 consecutive operations in which this drug was employed as an anesthetic agent, there was not a single death Anesthesia is achieved in a few seconds with a small quantity of the drug, the average amount ranging from 3 to 5 cc An objection to its use is its disagreeable odor, but it is now marketed in a scented form which renders it almost indistinguishable from eau de cologne With such a preparation a child may be anesthetized before it has time to realize the nature of the procedure It is administered by the open method

Vinyl Ether (Vinethene). Vinyl ether is a clear, volatile, colorless, inflammable liquid with an odor resembling that of garlic and a boiling point of 82 to 87°F Its use as an anesthetic agent was first suggested by Leake and Chen (54) As the pure drug is unstable, it is combined with 3 5 per cent alcohol and 0 01 per cent phenylanaphthylamin and bottled in an atmosphere of nitrogen It is marketed under the trade name of "vinethene" As an anesthetic agent vinyl ether is safe, provided its limitations are recognized It produces a rapid anesthesia, the induction time ranging between 50 and 90 seconds, and causes a muscular relaxation equal to that of ether, the respirations remain strong, the circulation is unchanged, and the period of excitement is so short as to be negligible Postanesthetic vomiting and pulmonary and renal complications are uncommon, although the drug has some toxic effect on the liver It has four times the potency of ether, but does not irritate the respiratory tract, and smaller quantities bring about a more rapid anesthesia It is more powerful than chloroform and is said to have a less depressing influence on the heart and liver and to

cause less postoperative acidosis. Unfortunately, the high volatility of the liquid renders difficult the maintenance of a long sustained, even anesthesia, therefore it is used chiefly as a preliminary induction agent to other inhalation anesthetics, such as ether and is employed for short ambulatory cases requiring muscular relaxation, when a gas machine is not available. Until its effect on the liver has been more clearly defined, operations lasting for more than half an hour had better be performed under an anesthetic agent whose action is better understood.

Vinyl ether is usually administered well diluted with air and by the open drop method. Anesthesia begins in 1 or 2 minutes, and only a small amount of the agent is required to bring about muscular relaxation. Recovery of consciousness is rapid and is comparable to that following the use of nitrous oxid (88)

Diethyl Ether (Ether) Ether still remains the most popular agent for operations requiring prolonged anesthesia and complete muscular relaxation. It is always available reliable, and efficient, and is safe in selected cases, even in the hands of a novice. Although it is not as pleasant to the patient as chloroform and requires a longer time for the induction of anesthesia, the margin of safety between the anesthetic and the toxic dose is wider

Ether is excreted by the lungs, kidney and stomach and therefore has an irritating effect on these organs. In the lungs it stimulates an increased secretion of mucus which predisposes to postoperative pulmonary complications hence, in the presence of respiratory diseases other anesthetic agents are preferable If, however ether must be resorted to under these circumstances, it should be used in reduced quantities, anesthesia being induced with nitrous oxid and oxygen, and just enough ether being added to secure the required relaxation. Because of its irritating effect on the kidney, ether is contraindicated in the presence of renal damage Its action on the gastric mucosa accounts for the frequency of postoperative nausea and vomiting following its use. It depresses the liver and causes it to liberate its glycogen, thus predisposing to hyperglycemia, hence it is contraindicated for unprepared diabetic patients. It should also be avoided in cases of severe anemias and in shock as it causes a reduction of hemoglobin and lowers the blood pressure by depressing the vasoconstrictors. Finally, because of its inflammability it is highly dangerous in the neighborhood of an open flame.

In the administration of ether the patient passes through the following stages (33) The *first stage* is marked by a burning sensation in the throat and a feeling of strangulation due to local irritation, by noises in the ear diminution of sensibility, and semiconsciousness. The *second stage* is characterized by excitement. The patient is delirious and violent, the face is flushed, the reflexes are exaggerated, the pupils are dilated and react to stimuli respirations are rapid, and the muscles are rigid. The *third stage* is that of surgical anesthesia. The patient is unconscious, the reflexes are abolished the pupils are contracted and do not react to light, respirations are slow, deep and regular and the pulse is full, strong, and slow If anesthesia is inadvertently carried beyond this stage the patient passes into a *fourth stage*, manifested by collapse. The pupils are dilated and do not react to light, the skin is cold, moist, and dusky, the pulse is rapid and weak the respirations become slow shallow and irregular and death results from asphyxia due to paralysis of the respiratory center

Chloroform Chloroform except for its toxic effects on the parenchymatous organs and its narrow margin of safety would be the ideal anesthetic agent, as it affords a

perfect anesthesia. Induction is rapid and pleasant, accompanied by little excitement and no irritation to the respiratory tract, relaxation is excellent, and recovery is marked by only slight nausea and vomiting. Another favorable feature of the agent is its non-inflammability, which permits of its use near an open flame. But all these advantages fade into insignificance when balanced against its dangers. It has a severe toxic action on the liver and kidney even after short administrations. It is a powerful cardiac depressant, causing ventricular fibrillation and a rapid and progressive fall in blood pressure. If introduced over prolonged periods, it accumulates in the tissues and may give rise to late toxic symptoms resembling those of acidosis, notably vomiting, restlessness, jaundice, albuminuria, ketonuria, impaired consciousness, and coma. Because of these grave dangers chloroform is rarely used as an anesthetic, and then only as a supplement to nitrous oxid and oxygen anesthesia, in which case minimal quantities are administered by the open drop method. Its principal indications are for patients suffering from respiratory diseases and when other agents are contraindicated because of the nearness of an open flame.

Administration of Inhalation Anesthetics

A smooth anesthesia is essential to the success of any operation. A poor anesthesia not only is detrimental to the patient, but also disturbs the surgeon and hampers his technic. The management of the individual about to be anesthetized is discussed in detail on page 481. Briefly, the preanesthetic sedative is administered before the patient is called to the operating room. The mouth is freed of all foreign bodies. The polish is removed from the finger nails of female patients, since the color of the nails is frequently of assistance in determining the presence or absence of cyanosis. The bladder and rectum are emptied, so the patient will not soil himself during anesthesia. Immediately before the patient is removed to the anesthetizing room, the surgeon consults the clinical chart, noting the temperature, pulse, and respirations for any evidences of a late complication which may have arisen since the last examination. At the same time he sets the patient's mind at ease with a few reassuring words. The patient is transported to the operating room well covered, no conversation being permitted in the course of the trip. The clinical chart, x-ray plates, and anesthesia record sheet containing the following data are sent up with him:

Name	Date	Location in Hospital	No.
Age	Sex	Weight	
Physical Condition			
Diagnosis			
Laboratory Report			
Urine			
Blood			
Associated Diseases Affecting Anesthetic Risk			
Nature of Operation			
Preanesthetic Medication	Dose	Time of Administration	
Anesthetic	Total Quantity	Technic	
Respiration	Pulse	Blood Pressure	
Description of Operative Procedure			
Results			
Name of Operator			
Name of Assistant			

The ideal arrangement permits of the anesthetization of the patient on the operating table in a small room adjoining and opening into the operating theatre. He is placed in a comfortable position on the table with a pad laid under the lumbar region as a precaution against back strain. The arms are fixed to the sides by means of a towel passed under the body, the ends of the towel being wrapped around the wrists and fastened with safety pins. To avoid the risk of musculospiral paralysis, the elbows should not be allowed to hang over the edge of the table. When the patient has reached the stage of surgical anesthesia, he is wheeled into the operating room During the operative procedure it is desirable that the anesthetist have an unobstructed view of the field of operation, so that he may keep the patient in a plane of anesthesia compatible with the surgical requirement. When muscular relaxation is necessary, the patient is placed in the deep or third stage of anesthesia, but when the needs of the operator do not demand relaxation, he is carried in the light or second stage. Blood pressure pulse, and respirations are recorded at 5-minute intervals, and if the amount of blood lost is considerable, the readings are taken more frequently Airways must be kept free at all times since occlusion predisposes to shock The secretion of mucus is diminished by preoperative administration of atropin, and that which collects in the pharynx is aspirated with a suction apparatus or wiped out with a gauze-covered finger In the case of operations of the nose and mouth bleeding into the upper respiratory passages can be prevented by careful hemostasis, by suction removal of extravasated blood and best of all, by recourse to endotracheal anesthesia which permits of the packing off of the pharynx with gauze. Retching and vomiting during anesthesia can be obviated by a preoperative restriction of the food intake (p 485) and by the maintenance of anesthesia at the proper level. Should the operation be one of emergency, the stomach is emptied preoperatively, and, if necessary, the tube is left in place during operation. If vomiting occurs despite precautionary measures, the mask is removed, the head turned to one side, the pharynx cleared to prevent aspiration of the vomitus, and the mask replaced.

When the operation is about to be completed, anesthesia is lightened and respiration stimulated by the administration of 5 per cent carbon dioxid and oxygen An artificial airway tube is introduced and left in place until the throat reflexes are re-established When the operation has been completed, the patient is wheeled quietly to the recovery room, care being taken during transportation to protect him against drafts, jolting and unnecessary noise He is placed under the care of a nurse until he regains consciousness. He should not be left alone even for a brief period, lest there be an accident, such as a fall out of bed or obstruction of respiration through the aspiration of vomitus or a falling back of the tongue into the pharynx. The head is turned to one side and the jaw held forward, in order that the airway may be kept clear As soon as the patient regains consciousness, he is encouraged to inhale slowly and exhale rapidly several times at frequent intervals.

Open Method. In the open method of anesthetization the anesthetic agent is administered drop by drop on a gauze mask over a wire frame. In the hands of those with little experience this is the safest procedure, inasmuch as the inhalant must necessarily be introduced with a large admixture of air, and the danger of anoxemia is accordingly minimized. Even so however, when the responsibility has been entrusted to an inexperienced anesthetist the surgeon must keep a close check on the character of the respirations and the color of the skin While the method is simple, it is conducive to

chilling of the inspired air, thus necessitating an undue expenditure of body energy on the part of the patient for the maintenance of the normal temperature Furthermore, the induction is comparatively slow, and involves a needless waste of the anesthetic agent, much of which is lost in the surrounding atmosphere For these reasons the open method has been largely superseded by other more efficient technics

A mask consisting of 6 to 8 layers of gauze laid over a wire frame is held a few centimeters above the patient's face, and a few drops of the anesthetic agent are allowed to fall upon it As soon as he becomes accustomed to the odor, the mask is gradually lowered and the number of drops per minute increased The concentration of the anesthetic agent may be strengthened by wrapping a towel around the mask As soon as the muscles become relaxed and pupillary and corneal reflexes disappear, the patient is ready for operation Anesthesia should be maintained with a minimal quantity of the inhalant The pupils furnish the best index as to the plane of anesthesia During surgical anesthesia they are contracted and do not react to light Dilated pupils which fail to react to light signify danger, and demand that the anesthesia be lightened Conversely, return of the pupillary reflexes or attempts at vomiting indicate that anesthesia is too light and call for an increased dose of the agent In order to maintain a free airway and prevent a falling back of the tongue, the lower jaw is held forward by pressure of the fingers behind the angle of the jaw. If respirations become obstructed, the tongue is pulled forward by means of gauze-covered fingers, a towel clamp, or a stitch passed through its substance Collections of mucus in the mouth are removed by suction or wiped out with gauze

Closed Carbon Dioxid Absorption Method In this method the anesthetic agent is administered in a closed circuit, thus permitting a rebreathing of the same gas, the exhaled carbon dioxid being absorbed by a soda-lime mixture The apparatus consists of an air-tight tract composed of a rubber mask designed to fit over the patient's face, a rubber rebreathing bag for the anesthetic agent, and a canister of soda-lime mixture placed between the face mask and rebreathing bag for the absorption of the exhaled carbon dioxid With each expiration the air passes through the soda-lime mixture, and the carbon dioxid is absorbed, a new supply of oxygen being continuously added (fig 200) Theoretically, there is no need of additional quantities of the anesthetic, but because some of the agent is bound to escape through the anesthetic bag and through the skin and wound of the patient, the amount thus lost must be replaced

Maintenance of anesthesia is best accomplished by this method Since the concentration of the anesthetic agent can be correctly maintained, the dangers of anoxemia and acapnia are eliminated Moreover, the depth of respirations can be accurately controlled, irrespective of the plane of anesthesia For instance, when deep respiration is required, as during the period of induction, the carbon dioxid can be increased, conversely, when shallow breathing is necessary, the carbon dioxid can be omitted (118) The patient breathes an atmosphere saturated with water from his own exhalations and heated by the chemical reaction between the expired carbon dioxid and the soda-lime mixture, thus warm moist air is in contact with the lungs at all times Another advantage of the closed system is that the inflammable gases are confined and thus are less likely to ignite Finally, the surgical team is not forced to breathe the exhaled anesthetic gas The chief difficulty presented by the method lies in securing an air-tight contact between the mask and the patient's face, but this can be largely overcome

by attaching the apparatus to an endotracheal tube and packing off the pharynx around the tube with gauze

Endotracheal Administration. Endotracheal anesthesia consists in the transmission of an anesthetic vapor through a wide-bore tube passed either nasally or orally into the trachea of an unconscious patient. The first to suggest the administration of an anesthetic through an endotracheal tube was Trendelenburg (1871) but the method did not meet with favor as it necessitated a tracheotomy for the introduction of the apparatus. In 1910 Elsberg (27) clinically introduced the insufflation method, whereby the anesthetic agent is blown into the trachea through a small tube under continuous pressure ranging from 20 to 30 mm. of mercury, the expired air issuing through the space between the trachea and the tube Although this method was occasionally resorted to until the end of the World War, it never came into general usage because of the inconveniences and dangers associated with the constant stream of blood or

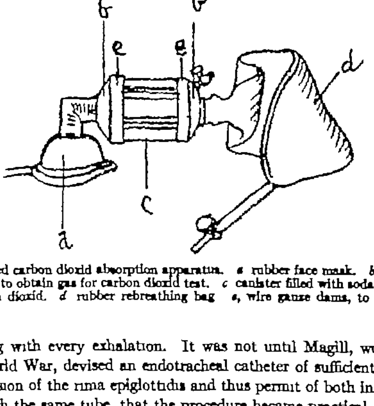


FIG. 200 Closed carbon dioxid absorption apparatus. *a* rubber face mask. *b* filter Distal end bearing stopcock, to obtain gas for carbon dioxid test. *c* canister filled with soda-lime for absorption of exhaled carbon dioxid. *d* rubber rebreathing bag *e*, wire gauze dams, to retain soda-lime in place. (Waters)

mucus escaping with every exhalation. It was not until Magill, working at Sidcup during the World War, devised an endotracheal catheter of sufficient caliber to effect complete occlusion of the rima epiglottidis and thus permit of both inspiration and ex paration through the same tube that the procedure became practical. This tube may be considered as a prolongation of the trachea into the outside air Through its lumen the anesthetic gas is delivered without pressure.

At the present writing the endotracheal method of anesthesia is generally accepted as the safest, most convenient and most economical means of administering an in halation anesthetic. Oxygenation is thereby maintained with the least possible effort on the part of the patient, since the anesthetic vapor passing through the tube takes the place of the supplemental and complemental pulmonary air, the anesthetic agent being delivered directly to the residual air As a result there is no need for active respiratory movements and a quiet, even anesthesia can be maintained for as long as 8 or 9 hours with the use of an extraordinarily small quantity of the inhalant. These features

render the method of special value in thoracic and in upper abdominal surgery, in which shallow breathing is an advantage In unilateral pulmonary conditions it is of particular advantage, as the tube can be introduced into the bronchus on the unaffected side and be made to cause a collapse of the lung to be operated upon It assures at all times a free airway over which the anesthetist has complete control Therefore, it is indicated in all operations in which the posture is such as to render direct attention to the airways inconvenient—for example, in cerebral, renal, and spinal surgery It is also advisable at times when the operative technic or the nature of the disease suggest interference with the airway Moreover, the endotracheal tube can be made to serve, if necessary, as an apparatus for the promotion of artificial respiration, a desirable feature in desperate risks The tube may also serve as a channel for the removal of fluid from the bronchial tree Finally, by doing away with the necessity of a face mask and by allowing the anesthetist to be at a distance from the field of operation, the method provides an unobstructed aseptic field, for this reason it is especially useful in operations about the head and neck

The arguments raised against the endotracheal method are the difficulty of intubation, the trauma occasioned by the passage of the tube, the danger of spreading infection, and the elaborate armamentarium required, but it would seem that none of these objections are insurmountable While the technic of intubation may seem formidable, in actual fact it is easily acquired The danger of introducing infection into the trachea from the mouth is negligible, provided the oral cavity is in a normal condition Injury to the lips, teeth, tongue, pharynx, vocal cords, and trachea by the laryngoscope, the endotracheal tube, or the packing can be avoided with ordinary care The initial cost of the somewhat elaborate armamentarium is soon compensated for by the economy in gas consumption Nevertheless, there are definite contraindications to the delivery of anesthetics by this method In the presence of infections in the respiratory passages there is the possibility that the septic material may be disseminated to other parts For mechanical reasons the method cannot be employed in the presence of malformations and neoplasms about the vocal cords, and it is inconvenient for operations on the pharynx, as the tube encroaches on the surgical field It is also contraindicated for operations on the eye, since the initial cough occasioned by the introduction of the tube may have disastrous results

The *armamentarium* consists of (fig 201) (1) An anesthetic machine with controlled delivery (2) A laryngoscope with a flash light battery handle for the introduction of the endotracheal tube under direct vision There are several varieties available, the most practical being those of Jackson and Magill, since they are illuminated by means of a self-contained battery and have a slot in the barrel wide enough for the accommodation of a large tube (3) Endotracheal tubes These tubes are made of pure or mineralized rubber and are available in different calibers and lengths—e g , 14 mm in diameter and 280 mm in length, 11 mm in diameter and 270 mm in length, and 8 mm in diameter and 180 mm in length—the choice depending upon the size and age of the patient It is essential to choose a tube that is of the proper length, as one that is too short easily becomes obstructed and one that is too long may pass into a bronchus and cause collapse of the lung on the opposite side The tube should be of such a caliber as to fit snugly into the larynx but not so tight as to traumatize the part Flagg (31) in 1927 devised a catheter made of metal and rubber, partly flexible and partly

rigid. These tubes are available in 3 sizes, designed respectively for infants, children, and adults (figs. 201–II) The principal objection to the Flagg tube is that it cannot be introduced through the nostril. To obviate the need of endotracheal tubes of different sizes, a tube has been devised carrying an inflatable cuff near its tracheal end (fig. 203) (4) Metal connection. A metal angle-piece connects the endotracheal tube with the short rubber tube attached to the gas machine. It is essential that this angle-piece fit tightly otherwise, the tube may be lost in the trachea. The balance of the armamentarium includes (5) a suction apparatus, (6) a 2-inch bandage boiled in soft paraffin for packing the pharynx, (7) a mouth gag, (8) a tongue forceps and a tube forceps, (9) an atomizer containing a 20 per cent cocain solution, and (10) sterile vaselin to lubricate the catheter

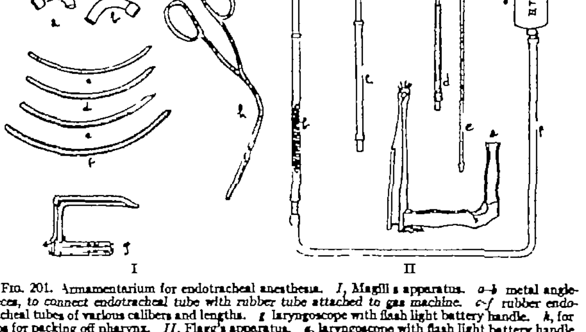


FIG. 201. Armamentarium for endotracheal anesthesia. *I*, Magill's apparatus. *a–b* metal angle-pieces, to connect endotracheal tube with rubber tube attached to gas machine. *c–f* rubber endotracheal tubes of various calibers and lengths. *g* laryngoscope with flash light battery handle. *h*, forceps for packing off pharynx. *II*, Flagg's apparatus. *a*, laryngoscope with flash light battery handle. *b* flexible rubber-covered tube with 9 mm. bronchoscopic tip *c*, same with 7 mm. tip. *d* same, with 5 mm. tip *e*, suction tube. *f* tubing connecting ether reservoir with catheter *g* ether reservoir

Technic Prior to the passing of the endotracheal tube the patient is placed under general anesthesia. This must be carried to the point of muscular relaxation, otherwise the contact of the tube with the vocal cords will result in spasm and interfere with the passage of the instrument. Magill (71) supplements the general anesthesia by a local desensitization of the upper air passages, employing a spray of a 20 per cent solution of cocain to which have been added a few drops of adrephin. He believes that such preliminary local anesthetization is of advantage, in that the intubation can be accomplished with a lighter general anesthesia. He also claims that if nasal intubation is to be employed, a maximum patency of the passage is thereby secured. Because of the toxicity of cocain however, it would seem that the advisability of a routine use of this drug is open to question.

The endotracheal tube may be passed in one of 2 ways (1) blindly through the nose, or (2) visibly by way of the mouth with the aid of a laryngoscope.

(1) *Nasal Intubation* This method is preferable to oral intubation, except when the operation is to be performed on the nose itself It can be carried out under lighter anesthesia, since the muscles of mastication need not be relaxed, it eliminates the risk of damage to the teeth and other oral structures, the insertion of the tube is somewhat simpler, and the need of a laryngoscope is eliminated Before the introduction of the tube the nose is inspected and the side offering the freest airway is selected If the mucous membrane is congested, the swelling may be somewhat reduced by spraying the parts with a 10 to 20 per cent cocain solution The patient's head is placed on a straight line with the trunk and raised so that the mandible forms a right angle with the table A soft rubber tube of the proper length and caliber is greased and introduced into the nostril, passed along the floor of the nose close to the septum as far as the pharynx, and advanced into the oropharynx until it reaches the glottis At this point a few whiffs of 10 per cent carbon dioxid are administered to deepen the inspirations and thus widen the glottis As the vocal cords separate on inspiration, the tube is

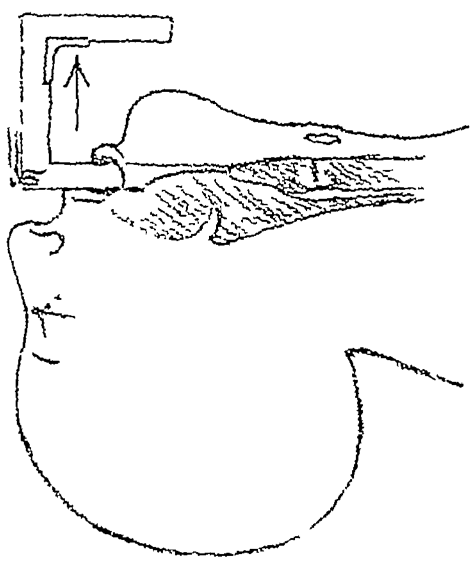
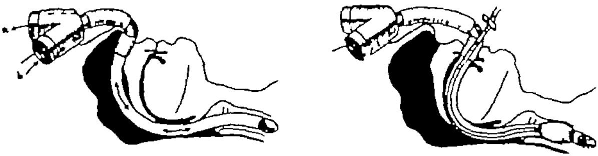


FIG 202 Position of laryngoscope for introduction of endotracheal tube

advanced between them If the proper precautions are taken to arrest the progress of the tube 5 cm below the vocal cords, the danger of passing it into a bronchus and causing a collapse of the opposite lung will be obviated Evidence that the tube is in the trachea is manifested by a blowing sound through the external end of the tube In the event that the tube does not pass readily into the trachea, its introduction will be facilitated by rotating it or by changing the position of the patient's head If in spite of these manoeuvers the tube cannot be advanced, no more force should be exerted, since this would only result in injury to the mucous membrane and cause the tube to curl up in the pharynx The tube in such a case should be left in place and guided between the vocal cords with the aid of a laryngoscop

(2) *Oral Intubation* For the ... of the endotr ... by way of the mouth the patient's head is placed ... position as f ... bation The mouth is opened, the tongue pushed ... the laryngos ... ed to the right of the midline, care being taken to a ... teeth (Fig ... trument is gently carried back until the pink ... into the ... on it is

advanced until the white glistening vocal cords are seen Without any alteration in its position the laryngoscope is then grasped with the left hand, the right hand being left free to pass the tube A well lubricated tube of the largest caliber capable of fitting into the trachea is passed along the right side of the floor of the mouth until the tip of the tube is brought into the field of vision in the pharynx. After a few whiffs of carbon dioxid have been administered for the separation of the vocal cords, the tube is guided into the trachea. A mouth gag is then inserted and the laryngoscope withdrawn. After the endotracheal tube is in place, it is joined by means of the metal angle-piece to a rubber connecting tube, which in turn is attached to the anesthetic machine (fig. 203) The taps in the cylinder are then turned on, and as soon as anesthesia is secured, the tongue is grasped and brought forward, and with the aid of a plugging forceps the pharynx is packed off with gauze lubricated with paraffin, vaselin, or albolene. Anesthesia is maintained in the ordinary manner prescribed for inhalation methods, either by the open or closed system If mucus collects in the tube and causes the respirations to become labored it may be cleared by suction. At the completion of the operation the packing is removed the endotracheal tube carefully withdrawn, and a metal airway introduced.



I II

FIG 203 Methods of introducing endotracheal tube. *I* nasal intubation. Metal adaptor attached to tube, to be connected with gas machine *a*, for exhalation. *b* for inhalation. *II* oral intubation, with tracheal inflatable cuff to obviate necessity of tubes of various calibers. (Burton)

COMPLICATIONS OF GENERAL ANESTHESIA

The major accidents which may occur during the course of general anesthesia are (1) respiratory collapse and (2) circulatory failure, both of which may be due either to an overdose or to an idiosyncrasy of the patient to the anesthetic agent. When evidences of the above calamities manifest themselves the operation should be terminated at once and symptomatic treatment instituted immediately, since the associated anoxemia will cause irreparable damage to the cortical neurons within a very few minutes (p 384) The carrying out of therapeutic measures with maximum speed and efficiency demands the organized assistance of the entire surgical personnel, each member being assigned a definite duty The anesthetist warns the surgeon of impending danger, removes the anesthetic agent, and places the patient in a 10 degree Trendelenburg position in an effort to maintain cortical circulation He then makes ready for intubation, in order to create an airway for artificial respiration. Meanwhile, one assistant institutes mouth-to-mouth insufflation to provide the patient with oxygen until the tube can be inserted. Coryllos believes this method of resuscitation more efficient and more rapidly effective than any other He says "In a number of in-

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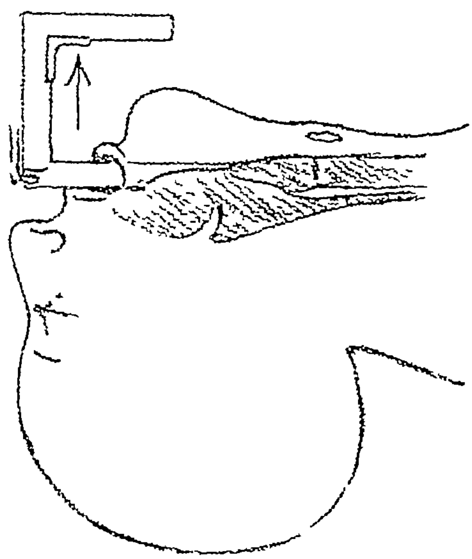

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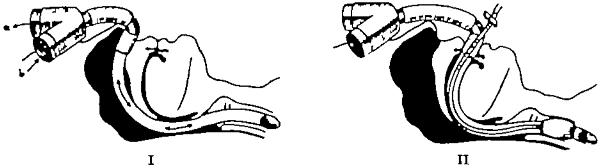
advanced until the white glistening vocal cords are seen Without any alteration in its position the laryngoscope is then grasped with the left hand, the right hand being left free to pass the tube A well lubricated tube of the largest caliber capable of fitting into the trachea is passed along the right side of the floor of the mouth until the tip of the tube is brought into the field of vision in the pharynx. After a few whiffs of carbon dioxid have been administered for the separation of the vocal cords, the tube is guided into the trachea. A mouth gag is then inserted and the laryngoscope withdrawn. After the endotracheal tube is in place, it is joined by means of the metal angle piece to a rubber connecting tube, which in turn is attached to the anesthetic machine (fig 203) The taps in the cylinder are then turned on, and as soon as anesthesia is secured, the tongue is grasped and brought forward and with the aid of a plugging forceps the pharynx is packed off with gauze lubricated with paraffin, vaselin, or albolene Anesthesia is maintained in the ordinary manner prescribed for inhalation methods, either by the open or closed system. If mucus collects in the tube and causes the respirations to become labored, it may be cleared by suction. At the completion of the operation the packing is removed, the endotracheal tube carefully withdrawn and a metal airway introduced



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stances with patients apparently dead, this method has produced striking resuscitations Physiologically this is a sound procedure because it allows the immediate administration of the correct mixture of carbon dioxide and oxygen, under the correct conditions of temperature, moisture, pressure and at the proper intervals" Another assistant prepares the field for intracardiac injection, and a third stands ready to administer fluids intravenously (p 362) The surgeon and nurse maintain asepsis in order that subdiaphragmatic massage of the heart may be resorted to, should it become necessary

Respiratory Failure There are many methods of resuscitation Laborde's technic, introduced in 1894, of exerting rhythmic traction on the tongue is of questionable value There are on the market a number of mechanical devices for the promotion of artificial respiration These machines are based on the principle of suction and pressure and take the form of lung motors and pulmotors, one example being the apparatus of Tinker and Emerson But these require the placing of the patient's body in chambers and are rarely practical in the operating room The most effective method of resuscitation is the following A large-bore endotracheal tube is introduced into the trachea under direct vision with the aid of a laryngoscope, and through this tube is administered 95 per cent oxygen and 5 per cent carbon dioxid Normal rhythm is simulated by pressing the contents of the rebreathing bag into the tube 20 times per minute During the inspiratory phase the nose should be kept closed to obtain maximum inflation In the expiratory phase manual compression over the chest will facilitate emptying of the lung While the tube is being passed, artificial respiration is maintained according to Sylvester's method, so that manipulation can be carried on with the patient in the dorsal position, and asepsis need not be imperiled Pressure over the carotid sinus may be of value in stimulating the respiratory center

Circulatory Failure To combat circulatory failure both mechanical and chemical measures are employed The heart can be stimulated mechanically by pressure on the thorax, percussion over the precordium, massage of the abdomen, direct stimulation through the diaphragm, or the forcing of solutions into the blood vessels If there has been an abdominal incision, subdiaphragmatic massage may be attempted with the object of activating the heart, but the possibility of cardiac massage through the intervening diaphragm seems questionable As a last resort, rather than give way to hopeless resignation, it may be advisable to incise the diaphragm, place the hand in the thoracic cavity, and compress the heart directly In this manner the ventricles can be completely emptied and blood forced into the circulation Attempts should also be madê to counteract the fall in blood pressure by the parenteral introduction of fluids (Chapter V)

The use of drugs for the stimulation of the circulation is of little value Epinephrin is one of the agents most frequently employed for the purpose, as it stimulates the myoneural junction between the nerve endings and the heart muscle It may be injected directly into the pericardium, heart muscle, or cardiac cavity, or it may be introduced intravenously If injected into the heart muscle, 1 cc of the drug in 1 1000 solution is introduced through a long needle inserted to the left of the sternum, in the fourth intercostal space In this way the heart is stimulated not only by the action of the drug, but also by the irritating effect of the needle puncture Such injections have the disadvantage, however, that they are likely to produce extrasystole or

ventricular fibrillations, conditions incompatible with life Hyman believes that these unfavorable consequences can be avoided by the introduction of the drug directly into the cardiac cavity He inserts a slightly curved needle, 13 cm. long, into the third interspace, as close to the right sternal margin as possible, directing its course toward the midline under the sternum and into the right auricle. If the drug is introduced intravenously, it is delivered in the form of a glucose or saline infusion (p 349) This mode of administration eliminates the dangers incident to direct cardiac injection—namely, acute cardiac dilatation and ventricular fibrillation. A more recently advocated agent is coramin which is best administered intravenously in 5-cc. doses. This drug is a powerful cardiac stimulant, exerting its principal effect on the medullary center It also stimulates respiration, even when the depression of the respiratory system is so great as to be unresponsive to carbon dioxid.

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CHAPTER VIII

PREOPERATIVE MANAGEMENT OF THE SURGICAL PATIENT

EVALUATION OF OPERATIVE RISK

A preoperative assessment of the surgical risk will largely determine the advisability of operation, the most appropriate time for its performance, and the choice of procedure to be adopted Indeed, such an evaluation is fully as important as the technical performance of the operation itself and imposes an equal responsibility upon the surgeon, for only by means of such an assessment can suitable measures be initiated to build up the patient's reserve, eliminate avoidable hazards, and carry him through a period of uncomplicated convalescence

The patient's ability to withstand the operation successfully demands consideration of (A) The operative demands of the pathologic lesion, (B) the physical status of the patient, and (C) the opposing weight of the two foregoing factors

Operative Demands of Pathologic Lesion Pathologic lesions may be classified as follows on the basis of their need for operative interference (1) Emergency lesions demanding operation at the earliest possible moment—irrespective of the patient's physical status—if his life is to be saved (2) Pathologic conditions causing ill health but necessitating no immediate surgical intervention Such cases afford ample time for a thorough investigation and control of the circumstances which have a bearing on the patient's recovery Fortunately, most operative procedures fall into this class (3) Lesions for which operation is desirable but not essential to life or health Unfortunately, in these cases there is a temptation to evaluate the surgical risk hastily and to prepare the patient inadequately for operation This temptation, if yielded to, may place the surgeon in a most unenviable position Patients have been known to succumb during a trivial operation because of an undetected coexistant condition, such as diabetes or hemophilia

Ability of Patient to Withstand Operation An attempt has been made to grade patients according to the probable effect upon them of an operation performed in the presence of associated organic lesions In such a grading due consideration must be given not only to those pathologic conditions which have an immediate influence on the operative procedure, but also those which have a bearing on the ultimate recovery For instance, a patient with a defective kidney may be able to survive an operation but may succumb several months later because of the added burden imposed upon the kidney by the anesthetic (1) *Good risks* are patients who present no adverse pathologic conditions and whose functional activities are normal (2) *Fair risks* are those who present organic lesions involving one or more organs and in whom the prospects of recovery from surgical intervention are somewhat below the average of the previous group Here are included patients with compensated organic lesions.

The defective organ, while capable of withstanding ordinary physical activity without undue disturbance of function, may break down when subjected to the extra strain of operation. (3) *Poor risks* are those suffering from a decompensated organic disease so serious as to be likely to prove fatal if the patient is subjected to operation.

Obviously, no clearly defined line can be drawn between good, fair, and poor risks, since a good risk may become a fair or a poor one at any time

Weighing of Demands of Operative Lesion against Patient's Physical Status While the foregoing factors have a certain practical value, they are inadequate in that they offer no basis upon which to evaluate the status of the patient whose surgical lesion is in itself likely to prove dangerous though no adverse organic conditions be present, conversely, they fail to take account of the patient suffering from severe organic disease but who presents but a minor surgical lesion A proper estimate of the margin of safety in any given case is possible only when the demands of the operative lesion are weighed against the patient's physical status

(1) *Lesions of an Emergency Nature* If the pathologic lesion is one of an emergency nature, the patient's physical status must necessarily be disregarded, since the risk incurred by an operation is less than that which would be entailed if the surgical condition were left untreated. Obviously, an emergency leaves no time for preoperative investigation and preparation, yet much can be done to carry the patient through the critical period of operation by the administration of restoratives the supplying of water and electrolytes by means of saline infusions and blood transfusions (Chapter V), and the institution of measures for the maintenance of body temperature. In view of the lack of time for adequate preparation, it is well to confine the operative procedure to the elimination of the immediate danger All other surgical measures should be postponed to a later time when the patient s condition warrants such interference.

(2) *Pathologic Conditions Responsible for Ill Health but Permitting of Operative Delay* In dealing with the class of patients known as *poor risks*, operations for pathologic lesions responsible for ill health but not necessarily dangerous to life should be avoided. But if the lesion is of such a character that, left untreated, it might result in death the decision will depend upon a consideration of the probable benefits to be expected from the operation on the one hand and the hazards which it imposes on the other If operation is decided upon patients in this group require rigorous preparation great care in the selection of the anesthetic, and keen judgment in the choice of that surgical procedure which will put the least amount of strain on the diseased organ. Only in this way can the margin of safety be widened.

In the case of patients considered as *fair risks*, surgery should be resorted to only after a careful regimen planned to convert the fair risk into a good one. The less radical of two or more possible operations should be chosen, in order to guard against further postoperative derangement of organs already damaged.

If the patient is a *good surgical risk* elective operations involve little danger, although it must be borne in mind that no operation is entirely free from hazards for despite the most painstaking preparation, complications may arise when least expected

(3) *Lesions in Which Operation is Desirable but not Essential* Obviously for this type of lesion operation is to be considered only in the case of patients who are excellent risks But even under ideal conditions such operations are not entirely free from danger There are always connected with every surgical problem certain indeter

minate factors over which the surgeon has no control and which he has no means of anticipating, even after the most painstaking study and preparation Apparently normal individuals may succumb during minor procedures because of some inexplicable cause ascribed variously to "vagal inhibition," "status lymphaticus," "mental shock," or "poor physical resistance"—all terms of unscientific vagueness but clear meaning Individuals vary widely in so-called natural resistance Some can withstand a difficult operation extending over a period of several hours, while under like circumstances the first few whiffs of the anesthetic may prove fatal to others Until the physiologist can supply the answer to the question of what constitutes "resistance," no operation can be considered free from danger

General Examination All candidates for operation, no matter how trivial the pathologic lesion presented, must be regarded as potential risks Therefore, a careful assessment of the patient's physical status, obtained through a searching scrutiny of his history, and thorough physical and laboratory examinations, is essential The information thus obtained may reveal organic defects of such a character as to alter the original choice of operation, postpone or contraindicate it, or show the need of special preoperative measures The importance of such an assessment has been stressed by Paget (63) "Never decide on an operation even of a trivial kind without first examining the patient as to the risk of his life You should examine him with at least as much care as you would for a life insurance It is surely at least as important that a man should not die, or suffer serious damage, after operation, as that his life should be safely insured for a few hundred pounds" Farnum (21) aptly remarks: "It is unfortunate but true that the neglect of obtaining a careful history and a competent physical examination on preoperative patients has been too often responsible for heart ache in the surgeon and heart failure in the patient" An academic discussion of the routine physical and laboratory examination is outside the scope of a book of this kind Such considerations as are given in the following few paragraphs are included merely to emphasize the importance of such procedures

The history should assume an important place in the course of every examination, since it frequently affords much valuable information and helps to throw light on the patient's background It may reveal a sensitization to various foods and an idiosyncrasy to certain drugs, both of which may have a potential bearing on the surgical treatment Should the patient give a history of a previous operation, its date should be noted, since a second operation performed before he has had time to regain his normal vigor may entail an additional hazard His former response to the anesthetic agent may disclose some sensitivity The condition of the operative scar may show a tendency to keloid formation Special data should be sought regarding the function of the heart, lungs, kidney, and blood to determine the ability of these organs to withstand the stress of the anesthetic A history of undue fatigue, palpitation, dyspnea, or chest pain after ordinary activity arouses suspicion of a serious myocardial deficiency, paroxysmal pain beneath the sternum is significant of angina pectoris Edema of the ankles and feet, accompanied by polyuria and excessive thirst, demands further investigation for evidences of renal deficiency Pain in the side, coughing, dyspnea, chills, fever, and sweats point to pulmonary conditions Headache, vertigo, impairment of vision, and paralysis may indicate some neurologic affection The family history may show a predisposition to various morbid states, such as mental disorders, malignancy, tuberculosis, diabetes, cardiorenal disease, or hemophilia

The physical examination should include a methodical survey to avoid the omission of any important detail.

The usual routine laboratory examination will afford information which, if intelligently interpreted, will do much to clarify the surgical problem. The results of these tests, however, should be subordinated to the findings obtained from the history and the physical examination. The laboratory investigation should include a urinalysis, a blood examination comprising quantitative and qualitative blood counts, a consideration of bleeding, clotting and sedimentation time and a routine Wassermann, Kahn or Hinton test for the detection of syphilis. Several examinations should be made, since a pathologic lesion may at one time show negative findings and at another give evidence of conditions that would postpone or contraindicate operation. Technically difficult and long-drawn-out procedures are for the most part unnecessary but if the data obtained from the routine examination presents a significant departure from the normal, further investigation is called for, its scope being regulated by the nature of the pathologic findings. Radiographic examinations are advisable when indicated, but their value, like that of all laboratory tests, should not be permitted to overshadow the results of direct clinical evidence.

Whenever malignancy is suspected, a *biopsy* is called for, except (1) when the lesion is so small that a total excision would entail but little additional inconvenience, (2) when it is so characteristic that the prognosis and the outline of treatment can be made without recourse to the procedure and (3) in obviously inoperable cases where only palliative treatment is to be administered. The specimen is obtained as follows. Under local anesthesia a section is excised from the center of the lesion with a scalpel, a pair of sharp-pointed scissors or a specially designed punch. A section of considerable size is obviously desirable, but one measuring only 2 to 3 mm. in thickness is usually sufficient for purposes of diagnosis. The remaining area is immediately coagulated and covered with a dressing. The specimen is placed in a 10 per cent solution of formalin and sent to the laboratory together with a brief history. While it is true that as a result of this procedure the malignant process may possibly spread into the adjacent lymphatics, the danger has probably been overemphasized. Stout (75) states "There is far more danger to the patient by not confirming the diagnosis than there is of probable spread of cancer by cutting into it." Removal of the section with an endotherm knife has been advocated on the grounds that such a measure will prevent metastasis by sealing the lymphatics, but this instrument renders differentiation of the type of lesion more difficult as the heat causes a distortion of the histologic relationship of the cells.

Martin and Ellis (53) advise that when the tumor lies beneath the surface of normal tissue, an aspiration biopsy be resorted to. After aseptic preparation of the area and infiltration of the puncture site with 1 per cent procain a stab wound is made through the skin. An 18 gauge needle attached to a tightly fitting record syringe (with the piston closed) is then inserted and advanced slowly through the superficial tissues until the point is felt to enter the suspected neoplastic mass. When the point of the needle is felt to enter the tumor the piston of the syringe is partly withdrawn so as to produce a vacuum (fig 204a), and the needle is then advanced 1 to 3 centimeters further depending on the anatomy and size of the tumor (fig 204b). Maintaining the vacuum, the needle is then withdrawn to the same distance, advanced again, and withdrawn, thus maintaining the vacuum constantly and keeping the

point of the needle within the tumor Tissue from the tumor mass enters the needle and is held within it both by a punch action of the advancing needle and by suction of the vacuum Before the needle is completely withdrawn from the tissues, the piston must be slowly released, the syringe detached, and the needle withdrawn separately (fig 204c) After complete withdrawal of the apparatus, the syringe is partially filled with air, again attached, and the contents of the needle slowly and carefully expelled on to a glass slide (fig 204d) The material may be prepared for examination by two methods one, the immediate fixation and staining of the smeared slide, and the second, the collected fragments, either alone or embedded in a blood clot, are fixed and treated as any small biopsy" Blair (4), however, believes aspiration of a potentially cancerous node "to be absolutely unsurgical, that a negative finding

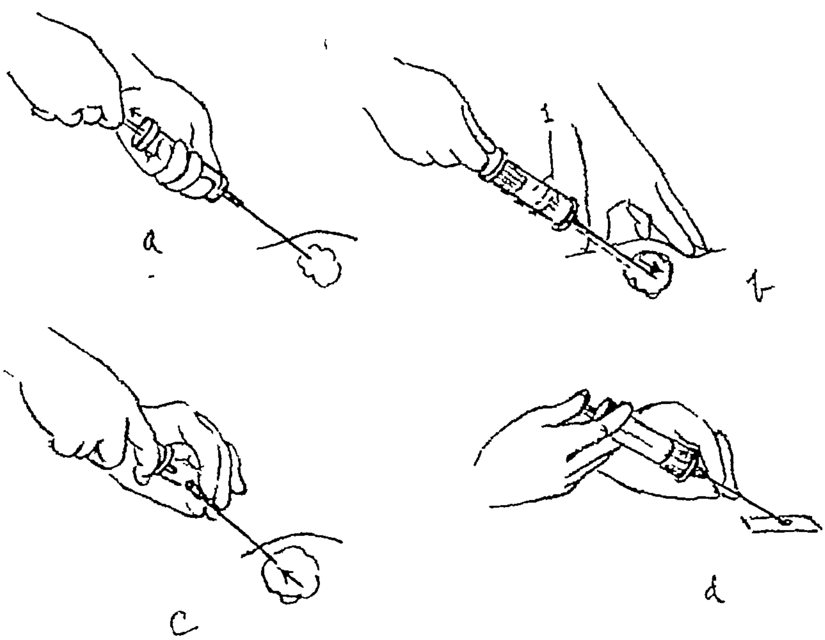

FIG 204 Technic of aspiration biopsy *a*, No 18 gauge needle attached to Record syringe inserted through skin until point enters tumor Vacuum produced in syringe by partly withdrawing piston *b*, maintaining vacuum, needle advanced and withdrawn to starting point Procedure repeated 2 or 3 times *c*, syringe detached from needle Needle withdrawn *d*, needle again attached to syringe, and plug of tissue in needle expelled onto glass slide For details, see text (Martin and Ellis)

would be without meaning, and that the procedure itself is not without grave risk to the patient if the gland is cancerous"

Although the value of histologic examination has been thoroughly and soundly established, pathologic variations are so common that clinical features must not be neglected in the confirmation of the diagnosis and in the outline of the campaign for treatment

Records Printed forms can be used to advantage to record the history and the physical and laboratory findings, and rubber stamp figures will be helpful in mapping out the pathologic lesion Sample forms of this kind are here appended

HISTORY

Name Date No

Address Telephone

Responsible Party
Address
Telephone
Referred by
Address
Telephone
Age
Sex
Marital State
Occupation
  Employed by
  Address
Telephone
Habits
Family History

Personal History
Present Complaint
  Onset
  Duration
  Progress

PHYSICAL EXAMINATION Date

Weight Height Pulse Temperature Respiration

A. *Topical*

Head

Including { Eyes / Nose / Ears / Mouth

Neck

Chest

Abdomen

Extremities

Genitals

B *Systems*

Skin

Gastro-Intestinal

Including { Mouth / Teeth / Tonsils

Genito-Urinary

Cardiorespiratory

Nervous

Glandular

LABORATORY EXAMINATIONS

A *Blood Test*

Erythrocytes $\begin{cases}\text{Number}\\ \text{Hemoglobin}\end{cases}$

Leukocytes $\begin{cases}\text{Quantitative}\\ \text{Differential}\end{cases}$

Coagulation Time

Bleeding Time

Sedimentation Time

B *Urinalysis*

Albumin

Sugar

Casts

C *Bacteriolic Test*

D *Radiographic Examination*

E *Biopsy*

REMARKS

Diagnosis and Record of Casts and Photos

Estimation of Operative Risk

Suggestions for Further Examination and Additional Laboratory Work.

A duplicate sheet recording the patient's history, clinical examination, and the results of the laboratory tests together with the x-ray findings is sent to the hospital by the surgeon and attached to the hospital record In turn, carbon copies of the latter are delivered to the surgeon on the patient's discharge In this way unnecessary duplication will be avoided, and office and hospital records will be made to conform

Various "shortcut" formulae have been suggested for a determination of the operative risk, but not one of them can take the place of the clinical picture obtained from a complete history and a thorough physical and laboratory examination, because the response of even healthy individuals varies so widely that no single standard is applicable to all cases When such formulae are applied to otherwise normal patients they are of little value, in the case of the abnormal they are helpful only in corroborating the evidence obtained from a complete examination

Among the more popular of the tests advocated are the following *Mott's formula*, whereby the pulse pressure in millimeters of mercury is multiplied by 100, and the product divided by the diastolic pressure, i e, $\frac{\text{pulse pressure} \times 100}{\text{diastolic pressure}}$ A variation of between 40 and 60 per cent is said to indicate a good risk, and a result below 25 or above 75 a poor risk *Sebrasez* (70) suggests a breath-holding test for the estimation of the cardiac and respiratory reserve The patient, resting comfortably in bed, is instructed to make a forcible expiration and then to refrain from breathing as long as possible A period of 25 seconds' suspended respiration is considered an indication of a good risk, while a duration of only 15 seconds or less would give evidence of a poor one *Strange* (76) reverses the above procedure by ordering the patient to hold his breath after a forcible inspiration If he can refrain from breathing for 45 seconds, he may

be classified as a good risk, but if for less than 30 seconds, he is a poor one. *Barack* (3) has advocated a test for the determination of energy index. The sum of the systolic and diastolic pressures in millimeters of mercury is multiplied by the number of heart beats per minute. The highest and lowest levels within the bounds of safety are given as 20 000 and 13 000. *Crampton* (11) tests the vascular tonus by a comparison of the patient's systolic pressure and pulse rate first in the recumbent and then in the upright position. The patient is made to recline, and his pulse rate and blood pressure are taken. He is then asked to stand for two minutes while the examinations are repeated. If the systolic pressure falls or the pulse rate increases, this is considered an unfavorable sign. The more marked the fall of pressure and the greater the acceleration of the pulse, the worse the prognosis. If the pressure remains stationary or rises, and there is little or no increase in the pulse rate, the patient is regarded as a good surgical risk. On the basis of these phenomena Crampton has devised a scale which balances the two influences so that there is but one value to consider instead of two. According to his scale, 100 represents theoretical perfection, a patient showing an index of 75 is looked upon as a good risk and one below 65 a poor risk. *Zanbrini* (82) believes that the resistance of the patient can be determined by the pH reaction of the saliva and has devised a test based on the changes produced in the saliva by the addition of a coloring reagent. A standard colorimetric scale is used as an index, the light shades indicating a poor surgical risk and the dark shades a good one.

FACTORS INFLUENCING SURGICAL RISK

PHYSIOLOGIC FACTORS

The physiologic factors which combine either to enhance or to jeopardize the prospect of a successful outcome of the operation will now be considered.

Age

Age exercises a considerable influence on the operative results. Generally speaking, patients in the second or third decades of life offer the best prognosis, while those in the two extremes of age are less favorable risks although the factors upon which the danger depends are not similar. Injuries or diseases considered trivial in the young adult are often a matter of grave concern in the very young and in the aged. The exact number of years, however, cannot be regarded as an index to the surgical risk since the degenerative manifestations of age are equally conditioned by heredity environment, and disease. A more dependable guide is the information obtained from the physical examination. According to the data thus secured, patients of 70 or over are not infrequently found to be good operative risks and comparatively young individuals poor ones. Various attempts have been made to determine the age-risk by means of laboratory tests. Carrel and also Lecomte du Noüy (50) believe that a precise relation exists between the age of the patient, the size of the wound, and its rate of cicatrization. Other investigators claim that an estimation of the inhibitory index of the blood serum can be employed to establish physiologic age. They have found that with advancing years there is a progressive change in the blood serum manifesting itself in an increasing inhibitory effect on the growth of tissue cells. This

they refer to as the "growth index" These tests are not as yet sufficiently precise or practicable to warrant surgical application

Infants and Children

There is an essential difference between the surgical management of infants and children and that of adults In the former the physiologic mechanism is more labile, the anatomic structure and size of the patient more delicate, and the surgical risk accordingly higher As Ladd (48) so aptly puts it "The surgeon who considers the child, or more particularly the infant, as only a small sized man is doomed to disappointment in the results of his treatment of this age group" The surgeon must base his operative procedure upon the lowest possible resistance of the child, rather than upon its maximum reserve Here the pediatrician contributes valuable aid not only by his capacity to evaluate the risk, but also by the resources at his command for bringing the child into the best possible state for operation, and his co-operation has done much to diminish operative mortality in childhood

Due to the instability of their life mechanism, children are especially prone to shock and may become alarmingly ill or even die before supportive measures can be instituted Hence, a more scrupulous consideration should be given to details relating to the conservation of body heat, the prevention of dehydration, and the control of hemorrhage Particular precaution must be exercised in the selection and administration of the anesthetic agent The small and fragile structure of the child demands a more refined technic in the manipulation of tissues and the use of more delicate instruments When possible, it is of a distinct advantage to divide the surgical procedure into stages rather than subject the patient to a prolonged operation Despite the many adverse surgical features presented by infancy and early age, children have remarkable recuperative powers, they recover quickly from apparently desperate conditions, their wounds heal well, and they are not unfavorably affected by prolonged confinement in bed

The factors demanding special consideration in the case of infants and children about to undergo operation are as follows.

(1) **Conservation of Heat** In the child the surface area of the body is relatively more than twice that of the adult and thus is capable of losing twice the amount of heat by means of surface radiation For this reason and because of the instability of the thermotactic center, greater care must be exercised in the maintenance of the body temperature The use of wet towels and evaporating solutions should be avoided

(2) **Risk of Infection** Since infants and children are more prone to infection than adults, every effort must be made to guard against concurrent exanthemata and other acute infectious conditions, especially those affecting the respiratory tract A history of exposure to a contagious disease contraindicates operation until the end of the incubation period and a rise in temperature constitutes a warning to defer operation until the cause has been eliminated.

(3) **Danger of Hemorrhage** These patients tolerate hemorrhage badly The blood volume in the adult averages approximately $\frac{1}{13}$ of the body weight, while in the child it is equal to $\frac{1}{20}$ and in infants to only $\frac{1}{12}$ of this weight Hence, 30 cc. of blood loss in an infant weighing 4 kilograms is equivalent to 540 cc in an adult of 72 kilograms Obviously, then, the surgeon must be more alert for symptoms of hemor-

rhage in children and must estimate the potential operative blood loss with reference to the size of the patient.

(4) **Likelihood of Metabolic Disturbances** Metabolic disturbances are not so well compensated in the child as in the adult. A relatively minor pathologic disturbance materially affects the glycogen reserve in the liver and leads to acidosis. Since in children only small quantities of carbohydrate can be stored in the liver, routine measures should be instituted to insure an adequate carbohydrate reserve and a proper acid base balance. This is best effected by means of a preoperative diet rich in carbohydrates The child should be carefully watched for symptoms of acidosis as indicated by the detection of ketone bodies in the urine and by evidences of increased respiratory ventilation, as manifested by hyperpnea. It is desirable that breast fed infants be nursed by the mother in the hospital up to the time of operation. If this arrangement is impracticable the milk may be withdrawn by means of a breast pump and transported to the child.

In young patients there is a great tendency to vomiting and diarrhea, and the consequent loss of fluid results in dehydration. If the fluid loss has been excessive 5 per cent glucose (15 cc. per pound of body weight) should be administered intravenously (p 350)

(5) **Possibility of Sudden Death.** An additional hazard in the case of infants under the age of a year and a half is the incidence of sudden death without demonstrable operative cause. Children subject to this danger present no special characteristics other than a moderate pallor, flabbiness, vascular hyperplasia, a tendency to rickets and an abnormal amount of lymphatic tissue with or without enlargement of the thymus gland While these symptoms are too vague to permit of a definite diagnosis, they are of sufficient significance to demand precautions. Marine (52) believes the cause to be "a constitutional defect, usually congenital, dependent on an inadequacy of some function of the adrenals, sex glands and autonomic nervous system and associated with lowered resistance or increased susceptibility to a great variety of nonspecific physical and chemical agents. Anatomically, it is characterized by a delayed involution or hyperplasia of the thymus gland, hypertrophy and hyperplasia of the lymph glands and lymphoid tissue underdevelopment of the chromaffin gonoidal and cardiovascular system and certain peculiarities of external configuration."

Paltauf (64 65) (1889) was the first to point out the relation between these sudden deaths and the above clinical manifestations, and it was he who gave to the syndrome the name of "status thymo lymphaticus" Since then much has been written for and against the potential responsibility of the thymus as an etiologic factor in sudden death The advocates of this theory believe that death results from pressure of an enlarged thymus on the trachea or on the vagus nerve. On this assumption they make a preliminary fluoroscopic check up of all infants with generalized adenopathies, in order to determine the persistence of the thymus gland and in the event of a positive shadow they advise preoperative x ray therapy to reduce the size of the gland.

It is questionable however whether this so-called status thymo lymphaticus actually exists, since pathologic observations have been based on varying standards in the size of the gland, and no constant abnormality has been found. Among those who deny the possibility of its existence are the Medical Research Council of Great

Britain (1926) and Greenwood and Woods (29), who assert that the term is a mere verbalism

Some believe that the so-called thymic syndrome has an allergic basis and bears no relation to the thymus gland, death being due to vagotonia and cardiac inhibition Waldbott (80) claims that a proposed skin test by means of the anesthetic agent or the administration of small amounts of the anesthetic followed by a quantitative eosinophilic count is of more value in the detection of the idiosyncrasy than a radiographic examination If this hypothesis is correct, it would seem that therapy directed toward desensitization would be preferable to irradiation Symmers' (77) theory has been summarized by Johnson (43) as follows. "The hyperplastic lymphoid tissue, especially in the naturally exposed situations of the upper respiratory and gastrointestinal tracts, is subjected to repeated minor chemical and toxic trauma, to which it reacts by focal necrosis, that in this process a specific nucleoprotein is liberated to which the lymphoid tissues become sensitized Subsequent exposure to the stimulus produces further necrosis and liberation of toxin, with an anaphylactic reaction varying according to the intensity of the stimulus, which reaction, if marked, is shown by sudden death"

Whether or not simple hyperplasia of the lymphoid tissue is causal of or incidental to the sudden death, it would seem that infants presenting evidence of lymphatic hyperplasia should not be subjected to operation if avoidable

(6) **Tendency to Nervous Instability.** The operative management of infants and children should be guided not only by their physical characteristics, but also by their mental and emotional make-up The young are inclined to be nonco-operative Their characteristic restlessness is apt to render immobilization of the affected part difficult and lead to displacement of dressings This difficulty may be partly overcome by means of judicious restraint For instance, following operations on the face and neck a light padded splint applied to the flexor surfaces of the elbows will prevent the child from contaminating the wound with his fingers In the case of children who are amenable and old enough to comprehend the circumstances, it is probably best to explain what is to take place and what is expected of them In the absence of such caution the fright occasioned by the strange surroundings may have far-reaching effects and may even result in psychologic maladjustment in later life For children who are intractable, basal anesthesia is often advisable Nembutal is well tolerated in doses adjusted to the age and size of the patient (p 399) It should be administered an hour before the anesthetic, for if the interval is shortened, the combined pharmacologic action of the nembutal and the anesthetic agent may cause a dangerous respiratory depression Should such an accident occur, coramin in 1- to 2-cc doses introduced intramuscularly or intravenously every 10 minutes will serve as an effective antidote

(7) **Choice of Anesthetic.** Since in children the margin of safety is less than in adults, the choice of anesthetic requires special consideration, and the agent chosen should be administered by a specially trained anesthetist In view of their higher metabolic rate children require relatively larger doses of anesthetics and sedatives than do adults Local anesthesia is the method of choice because of its safety, but unfortunately it can seldom be administered to children owing to their lack of co-operation As a general anesthetic ether is the most satisfactory agent under ordinary circum-

stances, although nitrous oxid and oxygen and ethylene-oxygen, despite the more harmful effects of the latter, have their place.

The Aged

Insurance statistics show that during the past 85 years there has been a definite upward trend in longevity (6, 81). Thus, according to Brooks (7), "in 1850, 2.6 per cent of the population were over sixty five years of age. In 1931, 5.4 per cent of the population were over sixty five years old. If the present trend continues for the same period as the present life expectancy period, the population will then contain 18.5 per cent, or more than twenty-eight million men and women above the age of

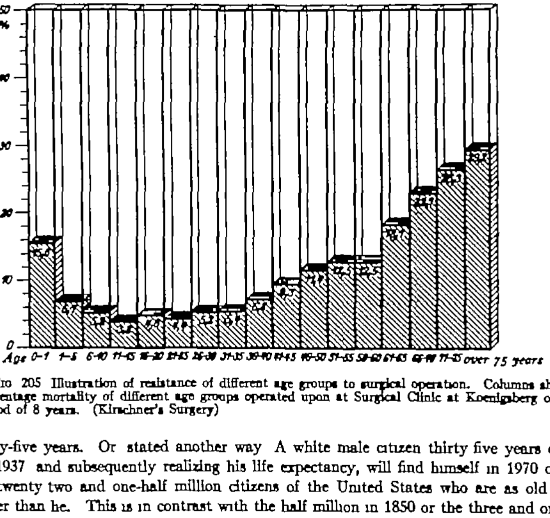

FIG. 205 Illustration of resistance of different age groups to surgical operation. Columns show percentage mortality of different age groups operated upon at Surgical Clinic at Koenigsberg over period of 8 years. (Kirschner's Surgery)

sixty-five years. Or stated another way A white male citizen thirty five years old in 1937 and subsequently realizing his life expectancy, will find himself in 1970 one of twenty two and one-half million citizens of the United States who are as old or older than he. This is in contrast with the half million in 1850 or the three and one-quarter millions in 1900." This definite trend toward longevity, together with the fact that the incidence of surgical disease increases with the years, has given the subject of old age added significance in its relation to surgery. Statistics also demonstrate that in persons beyond 40 the surgical risk increases progressively and that, generally speaking the age of fifty automatically removes the patient from the category of good risks (fig. 205). To illustrate—operations on the biliary system show a mortality of 2 per cent in persons between the ages of 20 and 40 and 9 per cent between 40 and 60. In a group of unselected surgical cases, Miller (56) found the mortality in patients over

50 to be 8 times greater than that in young adults, while Butler, Feeney, and Levine (8) reported that in the presence of cardiovascular degeneration the death rate after 50 was more than 3 times that before this period

Trivial operations, which cause little concern when performed on patients in the second or third decades, occasion considerable anxiety in those of advanced years An operation to which a young adult could be subjected without hesitation requires careful deliberation when contemplated for the aged The maximum potential benefits must be weighed against the operative risk, because in the case of elderly individuals even a slight error in judgment may lead to dire results

Like children, old persons are especially subject to shock and endure the loss of blood badly, but they have not the recuperative powers of younger patients and possess little reserve to aid them in combating the depressing effects of infection, dehydration, hemorrhage, and toxemia Their wounds heal slowly, and due to their sluggish metabolism, the period of convalescence is prolonged The mere placing of an aged person in a recumbent position is in itself a hazard because of the danger of pulmonary stasis and decubitus ulcers

Cardiac and renal efficiency are diminished with advancing years and should always be carefully evaluated before an operation is attempted Degenerative vascular changes are natural concomitants of old age, and the added burden placed upon the circulation during any operation may be sufficient to cause thrombosis and embolism and even rupture of the vessels Treves (78) states "Of all the conditions of disease or imperfect health which influence the result of an operation there is no graver complication than old age"

On the other hand, age is not entirely devoid of assets Anschutz (1) showed that of the patients under the age of 40 operated upon for carcinoma of the stomach only 5 per cent were living 5 years later, while of those operated on between the ages of 40 and 60, 18 per cent were still alive at that time, and of those over 60, 28 per cent

(1) **Preoperative Management.** While it is generally acknowledged that old people are poor surgical risks, the mortality may to a certain extent be reduced by recourse to measures which will conserve or increase their already limited reserve Lengthy preoperative hospitalization is of great value and often forestalls serious consequences It permits of ample time for the necessary examinations and for the building up of the patient's bodily chemistry, it also allows the patient to become familiar with his new environment and to adapt himself to it Generally speaking, the older the patient and the more extensive the contemplated operation, the longer should be his stay and the more painstaking the physiologic evaluation

The management of elderly patients requires of those in charge tact, patience, and judgment, and the ability to cope with the idiosyncrasies of old age They expect much attention and are inclined to be aggressive, selfish, and exacting They find it difficult to adapt themselves to their physical limitations and their new surroundings Those who are responsible for their care must try to win their confidence and surround them with an atmosphere of optimism The operation should be discussed as little as possible, and under no circumstances should it be suggested to the patient that advanced age increases the risk The fixed hospital routine usually proves irritating, and in order to prevent mental upsets it is frequently desirable that it be modified to meet the circumstances The patient should be made to feel at home and should be allowed to follow as nearly as possible his normal daily round of existence. Habits

of a lifetime should not be disturbed smoking and a limiting consumption of alcohol are not to be interdicted.

The diet should be regulated as far as possible to conform with individual tastes. It is especially important that the glycogen reserve of the liver be built up and maintained and this can be accomplished by the prescription of a diet rich in carbohydrates. Since these patients are usually dehydrated, a minimum of 3,500 cc. of fluid should be supplied daily (p 343) A check up of the renal function is especially important. Should the quantity of urine be below 1,500 cc. despite a high fluid intake, kidney elimination should be stimulated. If uremic symptoms are present, 50 to 100 cc. of a hypertonic (25 to 50 per cent) dextrose solution should be administered intravenously The dehydrating effect of this solution on the tissues can be counteracted by an infusion of normal salt solution Since the presence of anemia is especially hazardous in persons of advanced years, blood transfusions are advisable (p 352)

Great care must be exercised in the choice of the anesthetic agent, because the failing internal respiration and impaired elimination characteristic of old age predispose to more pronounced secondary toxic results Local infiltration and nerve blocking should be resorted to whenever possible. In cases where muscular relaxation is necessary the local anesthetic may be supplemented by small amounts of properly administered nitrous oxid and oxygen or ethylene-oxygen. In operations below the umbilicus, where local anesthesia is impracticable spinal anesthetics are preferable, except for nervous patients and those with low blood pressure Ether, chloroform, and avertin should be avoided when possible.

(2) **Operative Management.** In the case of an elderly patient much can be done during the operation to conserve his resistance Trauma can be minimized by a gentle handling of the tissues and shock largely avoided by the reduction of the operating time to a minimum

(3) **Postoperative Care.** The postoperative period should come under the personal supervision of the surgeon, in view of the greater predisposition of the aged to complications, notably intoxication hemorrhage pneumonia, embolism, thrombosis, and cardiorenal disease

Immediately after the operation the patient is placed in bed and kept warm. Fluids are administered (p 329) If there has been a considerable loss of blood, a transfusion should be resorted to In view of the deficient power of elimination in the aged sedatives like morphin and the barbiturates must be given with caution, as the incidental toxic effects are sometimes so pronounced as to cause mental confusion and prevent co-operation. Whenever possible, pain should be relieved by means of coal tar products, such as aspirin In order to prevent postoperative pneumonia, it is advisable to have the patient assume a semirecumbent position and to order frequent changes of posture if practicable. Deep breathing may be stimulated by inhalations of 30 per cent carbon dioxid administered for 5 minute periods every hour while the patient is awake If necessary coramin may be injected subcutaneously to enhance respiratory activity and assist in the expulsion of secretions. Due to the associated cardiovascular degeneration aged persons fail rapidly if allowed to remain in the recumbent position for any length of time For this reason they should be encouraged to leave the bed as soon as possible even at the sacrifice of some local benefits obtainable by a more prolonged stay

Sex

While women have less physical resistance and are more susceptible to nervous disturbances than men, they endure the pain of an operation with greater fortitude, are more tolerant of confinement, and adapt themselves more readily to the hospital routine Operative intervention during the periods of menstruation and pregnancy should be avoided, since the altered physiologic state at such times increases the operative risk Pregnancy involves the additional hazard of abortion During lactation elective operations should be postponed, since the albuminous drain induces an anemia which lowers resistance and increases the anesthetic danger Before puberty sex has little bearing on the surgical risk, after that time the female becomes a less favorable risk than the male, especially during the menopause Following the climacteric, however, her chances improve over those of males of corresponding age

The sex of the patient should be considered in planning the location of the incision, especially in operations about the head and neck When there is a choice it should be so planned in the case of women that the resultant scar will be concealed by the coiffure, while in men the best place would be in the region of the beard

Mental Status

It is a matter of common knowledge that the emotions have a definite bearing on the surgical risk and that a depressed psychic state is a potent factor in the production of undesirable physiologic reactions Cannon (10) has shown that emotional states, such as fright or anxiety, stimulate the sympathetic nervous system and cause a disturbance of the endocrine glands, which in turn are capable of bringing about metabolic and circulatory depression He states "In the case of strong emotional excitement, the internal environment of the body may be so affected as to determine for weal or woe, the fate of the whole organism" Crile (12) believes that adverse emotional stimuli initiate shock by exhausting the vasomotor centers (p 382)

No patient looking forward to an operation is free from some degree of apprehension, regardless of whether or not the fact is betrayed in his demeanor Patients may be classified as follows, in accordance with the amount of trepidation and outward manifestations they present (1) Those possessed of a placidly cheerful state of mind, making few inquiries, and meeting all circumstances cheerfully In the absence of other hazards, this type of patient offers the best prognosis (2) Nervous, loquacious individuals, haunted by exaggerated forebodings, who approach the operation with an "air of fluttering animation," who often require last-minute persuasion and frequently insist that the operation be delayed in order that they may alter their wills (3) The gloomy fatalistic type characterized by a morbid indifference or a hopeless resignation Patients in this group are apt to be poor risks Finney (22) relates that Halsted refused to operate on patients with the "I-shall-surely-die-if-operated-on" complex

A fearless, confident, psychic state of mind, manifested by "the tranquility which comes from hopefulness rather than the tranquility of hopeless resignation" undoubtedly will go far to increase the patient's resistance to the operative insult, prevent shock, and promote convalescence The significance of the mental outlook was recognized by the early surgeons Thus Henri de Mondeville in the thirteenth century

wrote "Encourage the patient with music of the sweet-stringed psaltery and with forged messages describing the death and confusion of his enemies or his elevation to a bishopric if he be a churchman.' Hunt (38) remarks "It is the mind which bears the burden of every illness and directs the adjustment of the individual to pain deformity and invalidism in all its various forms, so that any clinical method which ignores this master function of the body is gravely defective and may lead to serious error in interpretation and treatment.'

Much can be done to eliminate fear and establish confidence by congenial environment and optimistic suggestion. The patient's apprehension should be appreciated and allayed by explanations, reassurances and encouragement. This will require a proper estimate of the psychologic characteristics of the individual patient. Lack of understanding and sentimental over-sympathy are equally harmful. While the surgeon cannot promise that the operation, however slight, will be entirely free from danger, he can do much to put the patient at ease by stressing the benefits likely to be derived therefrom.

Habits

The operative risk is somewhat influenced by the patient's habits. Persons addicted to indulgence in alcoholic stimulants and other habit forming drugs, such as morphin, cocain, or the barbiturates, are under a distinct disadvantage, since a long-continued absorption of these poisons is bound to have a harmful effect on the tissues. Such patients react unfavorably to the anesthetic agent and are subject to mental derangement, their wounds heal slowly their resistance to infection is low, and they are more susceptible to such postoperative complications as pneumonia, dilatation of the heart, and kidney disorders In heavy smokers the respiratory tract is apt to be hypersensitive, hence, if a general anesthetic is to be employed, the patient should be cautioned to refrain from the use of tobacco for several days prior to operation In the case of drug addiction, however, the drug to which the patient is accustomed should not be withdrawn, since the sudden deprivation might lead to severe mental and bodily disturbances

Nutritional Status

The unduly fat and the unduly thin are both poor subjects for surgical operation and require a more detailed study than patients of average weight.

Obesity creates many problems. Its mere existence interferes with an accurate diagnosis, as it masks physical signs and renders Roentgen plates less significant. Thick masses of fat are easily mistaken for neoplasms, on the other hand, tumors may be buried so completely in adipose tissue as to escape detection or embedded so deeply that no diagnostic value can be attached to their presence. The induction and maintenance of general anesthesia in the obese patient is difficult, due to the impaired internal respiration associated with the suboxidation characteristic of the condition and special care must be taken not only to choose the proper agent but also to limit its action to the point of analgesia otherwise a dangerous state of anoxemia is likely to supervene (p 425) If a local anesthetic is to be employed the tendency of the poorly nourished tissue toward necrosis and infection at the site of infiltration should

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course of a year to a gain of 24 pounds. In the endogenous type it is necessary to postulate some dysfunction on the part of the endocrine glands While the basal metabolism is usually low, this factor cannot entirely explain the reason for the amassing of fat by the tissues For instance, in myxedema the basal metabolism is low, yet obesity is not a prominent characteristic. Clinically it is often impossible to determine the predominance of either endogenous or exogenous factors since the two conditions usually overlap

A pathologic loss of weight consequent upon defective nutrition definitely increases the operative risk In a group of 50 patients operated for peptic ulcer Studley reported a mortality of 33⅓ per cent among those who had lost 20 per cent or more of their body weight, as compared with a mortality of only 3.5 per cent among well nourished individuals. In the undernourished the proteins of the body tissues are called upon to compensate for the food deficit, and these demands are met selectively The serum protein of the blood is the last to be requisitioned and this is fortunate, since the osmotic pressure of the plasma proteins as opposed to the capillary blood pressure prevents the escape of the fluid from the vessels into the tissues. When the serum proteins are finally called upon and fall below 5.5 grams per 100 cc. of blood, the osmotic equilibrium is disturbed, and edema with its deleterious consequences supervenes (19) To forestall such consequences an estimation of the serum protein should always be made in the case of undernourished patients, and as soon as the level falls below normal—i e., 7.5 grams per 100 cc. of blood—blood transfusions are indicated, even in the absence of anemia.

The *management* of defective nutritional states requires the closest cooperation between the surgeon and internist. When the patient is an infant, it is essential to engage the services of a pediatrician in order to insure a proper supervision of the feeding In any case patients who are unduly over or undernourished should be hospitalized for at least 1 or 2 weeks before the contemplated operation. Obese individuals of the exogenous type require a decrease in the intake of calories and fat forming foods, so that their weight may be brought as near as possible to normal. Practically, this amounts to a diet of lean meats, fruits and vegetables with just enough carbohydrates and fats to relieve hunger and counteract weakness In addition to the diet a series of graduated exercises is prescribed, with the purpose of increasing the expenditure of energy Patients afflicted with the endogenous variety of obesity are given thyroid extract as an adjunct to diet and exercise. Conversely, the unduly thin require a greater intake of fat forming foods than patients of normal weight.

PATHOLOGIC FACTORS

Infection

Operation in the presence of infection, whether local or general, is fraught with danger, the risk depending on the location and type of the infecting organism Active infections gain headway and quiescent lesions are apt to flare up under the irritating stimulus of the anesthetic and the stress of operation The presence of general infection or a history of exposure to a contagious disease are sufficient to warrant a postponement of all but the most indispensable surgery until several months have elapsed

be borne in mind In the case of obese patients efficient cleansing of the skin is necessarily inadequate because of the increased depth of the natural folds, particularly in the axillary and submammary regions, the umbilicus, and the groin Furthermore, since the skin is thin, anemic, and flabby, it is especially prone to infection

Access to the pathologic lesion requires a longer incision, and dissection is difficult and time-consuming due to the depth of the wound and the thick layer of slippery subcutaneous fat Control of hemorrhage is often a problem because of the relative inaccessibility of the vessels and the tendency of ligatures to slip The friability of the tissues and their low power of resistance renders them intolerant of buried sutures Because of the predisposition of the poorly nourished tissues to infection, drainage must often be resorted to with its consequent interference with primary healing The closure of the wound, owing to the thickness of the parts, imposes a strain on the approximating sutures, and the wound margins are apt to slough, especially if the tissues have been undermined Postoperative nursing and after-treatment of the obese are onerous Their unwieldiness increases the difficulty involved in the change of dressings, the administration of enemas, and other attentions Furthermore, the excessive weight of these patients frequently makes it impossible to afford them the advantage of being propped up in bed, when such a position might facilitate convalescence

Obesity not only presents mechanical problems but also entails definite pathologic hazards The heart is put under a continual strain in its effort to supply blood to the superfluous tissues, and at the same time its function is impeded by the pressure of the excess fat surrounding it As a result the cardiac reserve is reduced and the blood pressure increased Likewise, the accumulation of fat around and within the lungs interferes with their activity and predisposes to postoperative pulmonary complications (p 508) Prodger and Dennig (66) found the vital capacity of the lungs in the obese to be 12 25 per cent below that in patients of average weight The functional reserve of the kidney is also restricted and may be depressed by the anesthetic agent below the level of safety Obese patients are especially prone to acidosis, and the necessary prolongation of the time required for operation, due to the mechanical difficulties already mentioned, frequently leads to shock

The pathogenesis of obesity is not clear In the normal individual the balance between intake and output of energy is regulated by the appetite and the impulse to activity, both of which in turn are influenced by the function of the endocrine glands In the obese individual this regulatory apparatus is obviously at fault, but the underlying cause is still a matter of conjecture Some believe that the normal organism responds to excessive food intake by an increase in metabolism and that adiposity results from a failure of this compensatory increase On the other hand, there are those who attribute the condition to a defect in carbohydrate metabolism, wherein starches and sugars, instead of being metabolized into energy, are converted into fats and stored in the tissues

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Infection

Operation in the presence of infection whether local or general, is fraught with danger, the risk depending on the location and type of the infecting organism Active infections gain headway and quiescent lesions are apt to flare up under the irritating stimulus of the anesthetic and the stress of operation. The presence of general infection or a history of exposure to a contagious disease are sufficient to warrant a postponement of all but the most indispensable surgery until several months have elapsed

after the total disappearance of the infection Local foci of infection should also be eradicated before subjecting the patient to operation, inflamed tonsils and sinuses should be treated, and septic teeth beyond the possibility of saving extracted Even in an apparently healthy mouth the teeth should be scaled and the mouth frequently sprayed with a mild antiseptic solution, since even in the absence of active infection potentially pathogenic organisms present in the oral cavity and upper respiratory passages constitute an ever-present menace when the power of resistance is lowered Any type of infection in the field of operation, such as acne, boils, and carbuncles, or any acute inflammatory process, interdict surgical intervention Such infection may spread to surrounding areas and entail serious complications even after a comparatively trivial operation In chronic inflammatory conditions the question as to the advisability of operation is debatable, and a decision must be made in each particular case For instance, in the later stages of syphilis the disease is usually not considered a bar to operation, provided the patient has received adequate antisyphilitic treatment, is not cachectic, and is not suffering from visceral disorders

When infection is suspected, total and differential leukocyte counts should be made The former furnishes an index to the patient's resistance, while the latter determines the severity of the infection A high leukocyte count with a preponderance of polymorphonuclear cells is indicative of infection and should be followed by an estimation of the blood sedimentation rate

The *sedimentation test* is based upon the fact that when blood is added to an anticoagulant, such as citrate or oxalate solution, the red blood cells settle, leaving a clear plasma above Certain inferences can be drawn from the rate of settling Rapid sedimentation occurs in conditions characterized by inflammation, suppuration, and tissue destruction A decrease in the rate indicates that these phenomena are subsiding Thus a marked increase followed by a decrease toward the normal level is interpreted as a good prognostic sign The reason for the greater rapidity of sedimentation in infectious processes is still obscure but has been ascribed variously to an alteration in the electrical charge of the erythrocytes, changes in the number of these cells, increased viscosity of the plasma, and certain chemical changes in the blood

Various methods have been employed for the measurement of the distance through which the red blood cells fall in the space of one hour Bannick, Gregg, and Guernsey (2) at the Mayo Clinic employ a modified Westergren test which is both simple and practical "Five-tenths cc of a 3 8 per cent solution of sodium citrate in distilled water is placed in a tube, and to this is added 4 5 cc of blood that has been drawn from a vein with as little stasis as possible After the tube has been inverted several times to insure thorough mixing, a Westergren pipette is filled to the 200 mm mark and placed in a rack in a *strictly vertical position* at room temperature The height of the column of plasma is read at the end of one hour and reported in terms of millimeters of sedimentation in one hour " They set 20 mm per hour as the highest level of the normal sedimentation rate

Cardiovascular Risk

Although the very fear of the operation itself and its unavoidable interference with rest, as well as the action of the anesthetic agent, all have a deleterious effect even upon the normal heart, nevertheless, fully compensated organic heart disease adds

little to the operative risk, provided the lesion is recognized and every effort is made to put the patient in the best possible condition for surgery Even in the presence of serious cardiac lesions, the risk can frequently be improved by means of adequate preoperative management to such an extent that operation is no longer interdicted (8)

Slot (72) summarizes the cardiac operative risk in the following table

Subject getting about his ordinary work without dyspnea	No risk
Mitral regurgitation	No risk
Mitral stenosis	No appreciable risk
Aortic regurgitation	No risk
Mild angina	Slight risk
Auricular fibrillation	Risk increased by 2 per cent
Auricular flutter	Risk increased by 2 per cent
Coronary thrombosis	Severe risk
Syphilitic aortitis and aneurysm	Severe risk
Heart block	Medium risk
Arteriosclerosis	Added risk of 5 per cent
Venous congestion	Bad risk

The most serious cardiac lesions are coronary sclerosis and syphilitic aortitis

Evaluation of Cardiac Risk

In the evaluation of the risk involved in operating upon patients suffering from heart disease, the following factors must be considered the cardiac history the nature of the cardiac lesion, the state of compensation, the condition of the arteries, and the blood pressure.

History The history furnishes more reliable information regarding the cardiac reserve than does the physical examination, since it frequently reveals latent or unsuspected cardiac disease even in the presence of normal physical and laboratory signs (35) Conversely physical findings of a cardiac lesion coupled with a negative history add but little to the risk.

The patient is interrogated for symptoms pointing to myocardial weakness, such as breathlessness on exertion, precordial or substernal pain, attacks of fainting or giddiness, swelling of the feet, and the inability to walk up stairs without stopping Circumstances permitting, an attempt should be made to estimate his cardiac reserve by means of an exercise tolerance test. If the pulse rate returns to the resting level within 1 or 2 minutes, his condition is considered satisfactory Generally speaking, if the above symptoms are absent and the patient is capable of carrying out his daily round of activity without cardiac embarrassment, he can withstand the strain of operation and the effects of the anesthetic agent without serious consequences, irrespective of the physical signs

However a history of cyanosis, dyspnea following exertion, orthopnea, anginal pain or edema indicates serious impairment of function and the problem here is to determine whether the diminished cardiac reserve is sufficient to meet the extra demands imposed by operation In such cases, the decision to operate must be preceded by a careful physical examination of the cardiovascular system supplemented by roentgenographic and electrocardiographic examinations.

Grading of Cardiac Patients On the basis of subjective symptoms patients with

cardiac disease may be graded as good, fair, and poor risks according to the amount of effort which they can put forth without distress (1) *Good cardiac risks* are those with well-compensated cardiac disease, and differ from healthy patients only in their more limited cardiac reserve They do not suffer from palpitation, dyspnea, cyanosis, fatigue, or chest pain upon ordinary physical activity In this group the operative risk is only slightly increased (2) *Fair cardiac risks* are those with incipient decompensation, either congestive or anginal These patients experience undue fatigue, palpitation, dyspnea, and chest pain on ordinary exertion, and in their case operation should be postponed until their status can be raised by careful preoperative management to that of the good risks (3) *Poor cardiac risks* are those suffering from cardiac decompensation These patients present evidence of cardiac inefficiency even when at rest For this group all operations are contraindicated except such as are absolutely necessary for the preservation of life, and such as are designed to remove a burden from the heart itself, in order to permit it to regain compensation

Physical Examination. The mere elicitation of a *murmur* is of little significance, and does not necessarily indicate organic valvular disease since it has been demonstrated that 8 to 10 per cent of cardiac murmurs are purely functional, occurring in otherwise normal patients Moreover, even if the murmur is organic, it does not materially increase the risk in the presence of full compensation Nevertheless, should a murmur be found, it calls for a more careful scrutiny of the cardiovascular system for the detection of more serious disorders which might adversely influence the operative risk

Variations in cardiac rhythm, such as sinus arrhythmia, extrasystole, auricular fibrillation, and paroxysmal tachycardia, unaccompanied by cardiac embarrassment, have no great bearing on the surgical risk But when they exist in conjunction with an embarrassed heart action, the risk is materially increased, and under such circumstances operation should be deferred until the normal rhythm has been restored

State of Compensation. As has been said before, the majority of patients with cardiovascular disease withstand operations well, provided compensation is adequate But in the presence of decompensation, the risk is increased in proportion to the diminution in the cardiac reserve The trauma of operation, together with the disturbance of the peripheral circulation induced by the anesthetic, has a tendency to hasten the breakdown of the compensatory mechanism, and the impeded circulation and diminished blood pressure predispose to coronary thrombosis Aside from the direct cardiac hazard, there is the additional difficulty involved in the surgical manipulation of the water-logged tissues of these patients Their wounds heal slowly and are subject to bacterial invasion, postoperatively, there is a tendency to pulmonary congestion and infection Therefore, in all cases complicated with decompensating cardiac lesions only the most urgent surgery is indicated

The degree of compensation is proportionate to the amount of myocardial degeneration Unfortunately, such degeneration is difficult to detect because of the absence of definite physical signs It should be suspected in obese and elderly individuals with distant heart sounds and small pulse In such patients the physical examination should be supplemented by an electrocardiographic examination, and if the T wave is found to be inverted, diphasic, or of low amplitude, either in the first or second lead, the heart condition is a matter of grave concern Orthodiagrams and teleroentgenograms for the measurement of the cardiac silhouette also give valuable information.

The difficulty here lies in the computation of the size of the heart as compared with the height, weight, and sex of the individual. The importance of electrocardiographic and roentgenographic examinations has been shown by Foged and Geill (24) who found that in patients with similar clinical heart manifestations the mortality from heart failure was 1.1 per cent when the electrocardiogram and roentgenogram were normal, and 11.8 per cent when they were abnormal.

Condition of Arteries and Blood Pressure The systolic pressure, which denotes the arterial tension at the height of the cardiac contraction, does not remain at a constant fixed level, but fluctuates widely following physical activity, fatigue, worry, and excitement. Therefore, it cannot be relied upon as a guide to the cardiovascular condition, unless considered in conjunction with other factors. A high systolic pressure unassociated with organic lesions may ordinarily be disregarded. On the other hand hypertension in the presence of renal lesions arteriosclerosis, angina pectoris, hyperthyroidism, or diabetes automatically places the patient in the category of poor risks. Here the hypertension is compensatory and represents nature's attempt to maintain a functional supply of blood in the tissues. It is therefore essential that it be not disturbed by operation. In hypertensive cases, however, contrary to expectation the danger of operative hemorrhage is slight. This can be attributed to the fact that surgical hemorrhage arises principally from veins and capillaries, the tension of which is unaffected by a high systolic pressure.

An uncomplicated low systolic pressure offers no operative hazards, and constitutes, if anything, a favorable prognostic sign. But in case the low pressure has been occasioned by disease or shock the risk is increased in proportion to the degree of reduction.

The diastolic pressure, or the tension in the blood vessels when the heart is at rest, is less affected by physical activity and the emotions than is the systolic pressure, and it is therefore a more dependable index of the cardiovascular status. A sustained irreducible diastolic pressure of over 130 constitutes a serious drawback to operation. The pulse pressure, or the difference between the systolic and diastolic pressures, represents the working range of the heart. If it falls below 25 or rises above 75, operation is contraindicated. The normal ratio between the pulse pressure and the diastolic pressure is as 1 is to 2 and any marked variation from this ratio also increases the operative hazards.

Management

If the patient's heart is *fully compensating* he is kept in bed for several days prior to operation in order to promote physical and mental relaxation and to allow time for a more thorough study of the cardiac and renal curves. Cardiac stimulants and depressants should be withheld; digitalization is unnecessary and often harmful. If there is a need for parenteral fluid, special care should be taken in its administration lest a too sudden increase in the blood volume overload the circulation and lead to cardiac embarrassment. Liquid may be supplied in the form of isotonic salt solution or glucose, either subcutaneously in amounts up to 2,500 cc. daily, or intravenously. In the latter case it should be injected slowly as a venous drip (p. 366). When indicated transfusions of 600 cc. of whole blood or 100 cc. of 50 per cent dextrose solution may be given with safety.

The time for operation should be chosen with care. Since the coughing associated

with respiratory complications imposes an added strain on the already weakened heart, operations should be done, if possible, during the summer months when infection is least prevalent

In the presence of *decompensating lesions*, such as congestive or anginal heart failure, the risk may be materially lessened by adequate preoperative preparation and skilled nursing The diet should be light and the fluid intake restricted Absolute rest in bed is imperative until compensation is regained Indeed, clinical experience has shown that the benefits of rest are greater than those gained by digitalization Massage of the limbs will favor the venous return and should be followed by resistant exercise

Any anxiety and mental distress on the part of the patient should be allayed by means of sedatives designed to relieve the heart of the strain imposed by the emotional tachycardia If the milder hypnotics are insufficient, morphin may be resorted to In the case of individuals suffering from auricular fibrillation tincture of digitalis, 0 1 cc for every 10 pounds of body weight, is to be administered at 6-hour intervals Saturation will usually be obtained in about 3 days Should marked slowness of the heart, extrasystoles, or gastro-intestinal disturbances supervene, the drug must be discontinued Patients with heart-block require thyroid extract to raise their metabolism, caffein to sustain the heart, and nitrites to reduce the hypertension In the presence of edema diuretics, such as theobromin sodium salicylate 0 65 to 1 30 grams (10 to 20 grains), 3 times daily, and saline purgatives are advised To relieve pulmonary edema atropin is employed If the venous circulation is engorged—as manifested by cyanosis, failure of the right ventricle, and pulmonary edema—the heart may be relieved by recourse to venesection, 250 to 500 cc of blood being withdrawn

Postoperatively, hospitalization should be prolonged beyond the usual period and supplemented by a maximum amount of rest in bed, in order to avoid the danger of subsequent embolism

Anesthesia. In the presence of cardiovascular lesions local anesthesia by infiltration or nerve-blocking (p 417) is the method of choice, but care must be employed in the administration of the agent The patient should be in the recumbent position, the anesthetic solution should be neutral in reaction, and should be injected slowly at body temperature In hypertensive cases the customary addition of epinephrin should be omitted, since the latter agent raises the systolic pressure and may bring about an anginal attack Spinal anesthesia and avertin, except in cases of essential hypertension, are contraindicated because of their tendency to cause a sudden drop in blood pressure

Of the general anesthetics, nitrous oxid induces a minimal metabolic change and permits of rapid recovery, but unfortunately the associated venous congestion and the consequent anoxemia are distinct disadvantages While ether creates more metabolic disturbance and is followed by a slower recovery, it is more satisfactory in cardiac cases as it is mildly stimulating to the heart and does not lead to venous congestion Cyclopropane is a very desirable anesthetic in these cases, since it permits of a high degree of oxygenation In the administration of a general anesthetic the stage of excitement should be reduced to a minimum by preliminary sedation and rapid induction The anesthetic dose should be so [illegible] to permit of prompt recovery from its effects In order to minimize [illegible] the heart, special care should be taken to avoid obstruction [illegible] brea[illegible] operation the blood pressure, pulse, and respiration sh[illegible] [illegible] As a result of anes-

thesia the blood pressure is usually raised 10 mm. of mercury, when it begins to fall an increase in oxygen percentage is required. In the event of extensive hemorrhage glucose or saline infusions or blood transfusions are indicated. The former are preferably given subcutaneously, since large quantities introduced intravenously may further embarrass the circulation The color of the blood should also be kept under constant observation. An incision followed by slight bleeding or by hemorrhage of a blue-black color is indicative of cardiac failure and demands the prompt administration of a rapidly acting cardiac stimulant. The most valuable agent is epinephrin which may be given hypodermically in doses of 5 minims of a 1 1,000 solution, or 1 cc. of the solution may be introduced directly into the heart muscle. If epinephrin is not available, camphor 0.2 gram (3 grains) in sterile oil or coramin 1 cc. may be injected intramuscularly While strychnin exerts no direct action on the heart, it is a valuable vasomotor stimulant and may be administered hypodermically in 0 001 to 0 002-gram ($\frac{1}{60}$ to $\frac{1}{30}$ grain) doses at 6- to 8-hour intervals.

Renal Risk

No operation should be undertaken without a preliminary examination for the detection of renal damage, since an impaired kidney places the patient within the narrowest limits of operative safety All operations incur some degree of dehydration from fluid loss through perspiration, hemorrhage, possible vomiting and diarrhea, and a diminution in the fluid intake but the normal kidney, which is capable of excreting body waste in a small amount of urine of high specific gravity, is not materially affected by the additional load put upon it. A damaged kidney, however, is unable to concentrate the urine and can discharge the waste only in a large quantity of urine of low specific gravity Thus it follows that operation with its accompanying dehydration, if carried out in the presence of renal disease, results in a retention of waste products, the diseased organ being unable to find sufficient fluid to carry off the body excretions The varying changes in blood pressure during the course of operation may also seriously affect an already damaged kidney by their unfavorable influence on the urinary output. Urine is formed as a result of the combined action of the glomeruli and the tubules, the crystalloid substances and water of the plasma being filtered out through the glomeruli, and this filtrate being changed into urine in the tubules by a reabsorption of water and other substances. Since the process of filtration is regulated by blood pressure, it is logical to assume that any variation in pressure, however slight, must have an adverse effect on a defective kidney In the postoperative period the increased production of nitrogen, arising either from the absorption of broken-down pathologic tissue or from the increased metabolism of the frequently associated fever, imposes an additional burden on the kidney

With the above facts in mind it can readily be seen that any patient with an organic kidney lesion is a precarious operative risk, even under the most favorable circumstances, and before embarking upon any type of operation a meticulous weighing of the expected operative benefits against the probable hazards involved is essential. Fortunately in view of the modern advance in diagnostic procedures, as exemplified in intravenous urography ureteral catheterization, ophthalmic examination of the eye-grounds, urine and blood examinations, and renal efficiency tests, the functional condition of the kidney can be more or less accurately measured. Urinalyses should

be made at repeated intervals. The presence of even a slight trace of albumin would warrant further investigation to discover its source, for although it may be of extra-renal origin and due to vaginal, vesical, or urethral discharges, having little surgical significance, as a rule its presence is indicative of some disturbance in renal function. On the other hand, the absence of albumin does not necessarily give evidence of a normal kidney. The presence of granular or cellular casts points to an active, irritative, renal lesion, fatty casts usually presuppose a subacute glomerular nephritis, while hyaline casts point to a chronic interstitial nephritis.

A blood examination should be made to detect any abnormal retention of waste products. The normal non-protein nitrogen content is 35 to 45 mg per 100 cc, urea nitrogen 10 to 15 mg, and creatinin 0.5 to 1.5 mg. A material increase over these amounts indicates renal deficiency corresponding in degree with the amount of retention, and is a serious omen, since nitrogen retention does not begin until $\frac{1}{3}$ of the functional activity of the kidney has been destroyed.

If the above tests give evidence of renal deficiency, they should be supplemented by kidney-efficiency tests. There are many available methods which, when properly interpreted, are of great value in indicating the extent of the damage. (1) The fractional phenolsulphonephthalein test is useful in the detection of early kidney damage. Six decigrams of the agent are injected intravenously. Under normal conditions 55 per cent of the dye will be excreted in the urine within the first half hour, an excretion of less than 20 per cent within 2 hours would indicate definite functional impairment. (2) Fishberg's (23) concentration test is simple and practical. The bladder is emptied at 7 P.M., and all fluids are withheld. Samples of urine are collected and examined at 9.00, 10.00, and 11.00 o'clock the following morning. A specific gravity of less than 1.015 constitutes proof that the kidney is unable to concentrate the urine and is already functioning at full pressure. (3) The urea clearance test furnishes a delicate index of reduced renal function but is too technical and intricate for routine use (57, 79).

Although all organic lesions of the kidney add to the operative hazard, the risk is somewhat modified by the nature of the disorder. In acute nephritis the danger is so great as to contraindicate all but the most urgent surgery. In chronic parenchymatous nephritis, while the prospects are brighter, operation should be avoided when possible, since the associated edema increases the susceptibility to infection. Chronic interstitial nephritis incurs the least operative danger, but even here there is a likelihood of uremia and cerebral hemorrhage.

Management

In the case of patients suffering from organic renal disease the operative hazards can be somewhat minimized by means of prolonged an ... te preliminary treatment, a proper selection of th ... esthetic agent, a ... surgery. Since a damaged kidney is unable to c ... the urine, th ... e should be so regulated that the daily output ... tely 1,500 ... atient cannot take liquid by mouth, it is admini ... erally in th ... ormal salt solution. Should this lead to edema, a ... se solu ... substitut ... e administration of ... uids, ho ... nditione ... ovas ... which usually ... kid ... ogen ... acidos ... ent, can be ... a

40 grams and by a prescription of 7 to 8 grams of sodium chlorid and 2 to 3 grams of sodium bicarbonate daily If anemia is present, it is treated in the customary manner (p 470) The question of anesthesia is always a difficult problem The method of choice is local infiltration and nerve blocking but in cases where the nature of the operation demands a general anesthetic the safest agent is nitrous oxid and oxygen (p 425)

Blood Dyscrasias

The blood dyscrasias—namely, idiopathic and secondary anemias, leukemia, and purpuric states—are factors prejudicial to all operations. Since the tissues are largely dependent for their nutrition upon the velocity of the blood and its oxygen content, it is reasonable to assume that an alteration in the quality or quantity of the blood will delay healing, lower resistance to infection, prolong the period of convalescence, and predispose to embolism and thrombosis Hughson (37) reports a mortality 7 times as great in patients whose hemoglobin content was below 60 per cent as that in patients in whom it was 80 per cent. Besides the dangers incurred by the qualitative and quantitative changes in the blood characteristic of the primary anemias, the intoxication, malnutrition, albuminous drains, and hemorrhage responsible for the secondary anemias in themselves may lead to serious consequences The reduced blood volume in anemia imposes a tremendous strain upon the heart in its effort to maintain the blood pressure at a physiologic level. During operation the additional loss of blood, even though slight, is apt to interrupt the process of cardiac compensation, interfere with tissue oxidation, produce an accumulation of acid products in the tissues, and eventually bring about shock

The nature and severity of the anemia may be determined by an *erythrocyte count* and by an estimation of the *hemoglobin content* Primary anemias ordinarily show a high hemoglobin percentage with a low erythrocyte count, while in the secondary anemias the hemoglobin percentage is low and the erythrocyte count comparatively high If the erythrocyte count is less than 3,000 000 or the hemoglobin content below 60 per cent, no operation should be attempted without a previous blood transfusion *Total and differential leukocyte counts* should be made and interpreted conjointly A leukocyte count above 10 000 calls for a differential count. A preponderance of polymorphonuclear cells indicates the presence of an acute infection, while a predominance of lymphocytes signifies chronic infection. Should the leukocyte count exceed 100,000 per cubic mm. and many immature white cells be present, leukemia is to be suspected. If the blood dyscrasias are complicated by dehydration, the presence of anemia may be masked by the concentration of the blood.

A routine determination of coagulation and bleeding times should also be made. There is, however some doubt among competent clinicians as to the value of these tests. Experience has shown that prolonged bleeding and clotting periods do not necessarily indicate the likelihood of postoperative hemorrhage and that normal or shortened periods do not always give assurance of its unlikelihood (69, 39, 55 44) *Coagulation time* represents the period required by a small wound to stop bleeding The normal time is between 2 and 8 minutes. A convenient way to measure this period is to puncture the finger aseptically and draw the blood up into a glass capillary

tube After the space of 3 minutes small sections of the tube are broken off at half-minute intervals to detect the presence of fibrin threads between the broken parts *Bleeding time* is the interval between the appearance of the first drop of blood following a skin puncture and the cessation of bleeding It normally lasts between 2 and 3 minutes In order to measure this period the lobe of the ear is punctured, the time of appearance of the first drop noted, and each subsequent drop immediately absorbed with filter paper, care being taken not to touch the skin The moment at which bleeding ceases is noted and the period designated the "bleeding time"

Management

Before an operation is undertaken on anemic patients, measures must be adopted to bring their physical condition to an optimal state Exposure to the sun's rays, a high caloric diet, feeding with liver or liver extract injected intramuscularly, and the administration of iron, arsenic, and copper will do much to build up resistance. If the clotting time is found to be delayed or the bleeding time increased, the prescription of calcium lactate or calcium gluconate for a number of days previous to operation is believed by some clinicians to reduce the tendency to hemorrhage

Preoperative blood transfusions should be resorted to as part of the customary routine, since they ideally fulfil all the requirements of the anemic patient Blood transfusion raises the erythrocyte count, increases the hemoglobin content and the blood pressure, it diminishes the coagulation time, helps to correct the acid base imbalance, accelerates healing, and prevents shock Postoperatively, a properly matched donor should be on hand The amount of blood required will vary with each individual case, but usually 500 to 600 cc are sufficient Two or more transfusions are sometimes necessary The blood should be introduced slowly, since the added volume augments the work of the heart in a geometric ratio—for instance, when the blood volume is trebled, the cardiac activity is increased 9 times Thus in the anemic patient, with his degenerated myocardium, a too rapid delivery may cause acute dilatation of the organ

Before the administration of a blood transfusion for the purpose of restoring a failing circulation, one should make certain that the underlying cause of the condition is a lack of blood volume and not an acute cardiac dilatation In the latter case a blood transfusion would have serious consequences, since here the heart is already overdistended with blood If it becomes necessary to administer the transfusion during or immediately after active hemorrhage, the moment chosen should be that at which the blood pressure has fallen to a point where cerebral anemia induces fainting—the so-called fainting point, otherwise, the additional pressure induced may result in an increase of hemorrhage or its recurrence

The administration of an anesthetic in the presence of blood dyscrasias involves special hazards It has been estimated that the average general anesthetic reduces the oxygen-carrying capacity of the blood about 25 per cent It follows, then, that a patient with an initial 70 per cent hemoglobin content will, under the influence of an anesthetic, be placed in the same danger zone as one showing a hemoglobin content of 45 per cent Therefore, the anesthetic agent should be one which can be administered in combination with a high percentage of oxygen, such as cyclopropane Ether and chloroform are contraindicated

Hemophilia. The possibility of hemophilia, a condition transmitted by the female to the male member of the stock, constitutes an ever present menace, since no objective signs are visible and no abnormality can be detected in the quality quantity, or coagulation time of the blood prior to operation. The usual coagulants—namely, thrombokinase, thrombin preparation, calcium salts parathyroid extract, and foreign proteins—as well as heat, ligation, and the use of styptics, are ineffectual (36), and if the tendency to this condition escapes notice, even a minor operation may induce serious or even fatal hemorrhage. Therefore careful inquiry into the family history should always be made in an effort to ascertain the presence of this idiosyncrasy

Obviously in the case of hemophiliacs only operations of the utmost urgency should be performed and these should be preceded by repeated blood transfusions. Recently McFarlane and Barnett (54) have discovered the local application of the poison of the Vipera russellii to be valuable in the control of hemophilic hemorrhage The part is cleansed of blood with hydrogen peroxid, and a piece of wool soaked in a 1 10,000 solution of the venom is placed on the bleeding surface. The use of this agent, it is claimed, has made possible in hemophiliac patients minor operations which hitherto would have proven fatal. Moccasin venom, in daily doses of 0 1 cc. for a week or two before operation, has also been successfully resorted to Because of the sex-link factor involved in the transmission of the disease, the use of female hormones has been suggested for the control of the bleeding Eley (17) of Boston has experimented with human placental tissue and claims to have found it locally efficacious. Placental extract, administered orally is said to be effective within 15 to 20 minutes, the beneficial *results lasting from 2 to 9 days*

Respiratory Risk

Operation on persons suffering from respiratory disorders involves serious hazards Even in the presence of a normal respiratory system there is always the danger that the ever present potentially pathogenic bacteria lurking in the upper air passages may spread downward when the patient s power of resistance has become lowered by the anesthetic and operation Obviously actual respiratory lesions are even more likely to result in complications. Quiescent lesions may be activated and active processes intensified, and the associated coughing not only puts a strain on the heart, but also threatens the security of the suture lines Chronic pulmonary diseases, such as bronchitis, phthisis, and emphysema, offer fewer hazards than do acute conditions such as acute bronchitis, coryza and lung infection, provided there is no secondary cardiac lesion or associated obesity Asthmatic patients usually withstand operations well and not infrequently enjoy a prolonged period of respiratory freedom after recovery from anesthesia.

When pathologic changes in the respiratory tract are suspected, a complete physical and roentgenographic examination of the lungs, together with an estimation of the vital capacity, is essential. Any change in rate, rhythm, or amplitude of the excursions should be investigated. A decreased amplitude indicates an impairment of vital capacity Limited movement of one side of the chest raises the suspicion of pleurisy, pulmonary lesions, or impairment of the diaphragm on the affected side. Radiographic examination may reveal pathologic pulmonary lesions of such a character as to contraindicate operation.

Interference with free ventilation of the lung is the most potent single factor leading to postoperative complications, and for this reason the vital capacity should be previously estimated, in order to determine the degree of functional impairment. This is accomplished by means of a spirometer. The patient fills his lungs fully and expels the air forcibly into the instrument, and the vital capacity is measured on an appended scale. The average reading is about 3,500 cc., varying with the age, weight, and sex of the patient. Diminution of the vital capacity results in a directly proportional increase of the surgical risk. A reduction below 50 per cent of normal would discourage operative interference and suggest further examination of the respiratory and cardiovascular systems.

Management

Chest complications can be guarded against preoperatively by the removal of foci of infection in the mouth and pharynx and careful attention to oral hygiene. The teeth should be scaled, septic roots removed, cavities temporarily filled, and the mouth systematically cleansed with a brush dipped in an antiseptic solution. Operation should be avoided if possible in the case of patients suffering from "cold in the head," unaccountable temperature, acute bronchitis, or pulmonary infection and in those who have recently recovered from an acute respiratory disease. Since anemia, malnutrition, and dehydration predispose to pulmonary embolism, measures should be directed toward the relief of these conditions before any attempt at operation. The most important single factor in the production of postoperative pulmonary complications is an increase in the amount of bronchial secretions. Therefore, in patients subject to excessive secretion atropin should be administered, as it not only diminishes the discharge, but also stimulates the respiratory center. The drug is administered hypodermically in 0.00065-gram ($\frac{1}{100}$ grain) doses at hourly intervals before operation. Because of its cumulative effect not more than 3 doses should be given. During operation suction should be employed to remove the secretions which have collected in the pharynx and trachea.

The choice of *anesthetic* and the skill exercised in its administration are of the utmost importance in the presence of respiratory disease. Local anesthesia is preferable when the surgical condition permits. While it is not a safeguard against pulmonary complications, it does eliminate the risk of aspiration pneumonia, one of the precursors of pulmonary collapse. If a volatile anesthetic cannot be avoided, its quantity should be cut to a minimum and its irritating effect on the lung reduced by the preliminary administration of a basal narcotic (p. 399). When the vital capacity of the lung is low, an agent should be chosen which can be administered in combination with a large percentage of oxygen. Nitrous oxid and oxygen may be chosen, but cyclopropane best answers the purpose. Ether should be eschewed if possible, but if its use is unavoidable, the vapor should first be warmed (71).

During the administration of the anesthetic special precautions should be taken to prevent collapse of the lung, inasmuch as many postoperative complications take origin in atelectatic areas. Although there is evidence to cast doubt on the efficacy of carbon dioxid as a promoter of pulmonary ventilation, nevertheless its administration in a mixture of 5 to 10 per cent concentration combined with 50 per cent oxygen is of definite advantage. During the period of anesthesia it stimulates the respiratory cen-

ter and enables the anesthetist to control the depth of the respirations, thus maintaining a full degree of pulmonary ventilation and preventing the accumulation of secretions. Administered at the completion of anesthesia, the artificial hyperpnea it produces washes the anesthetic out of the circulation and leads to a rapid de-etherization. Thus it is efficacious not only in alleviating the prolonged irritating effect of the anesthetic agent during a period in which the respirations are necessarily diminished and circulation is sluggish, but also in bringing about an early return of the cough reflex which aids in the expulsion of the ether-laden secretions. In patients with respiratory impairment the period of anesthesia should be reduced to a minimum and the agent withdrawn before the end of the operation, so that the cough reflex may be present when they leave the operating room.

As has been said before, any interference with expansion of the lung bases predisposes to respiratory complications. Therefore, care should be taken to eliminate any mechanical factor which might embarrass breathing. The patient should be placed on the operating table in a position favoring full expansion of the lung. Constricting bandages and heavy dressings which impede respiratory movements are to be avoided. The duration of the operation should be as short as is consistent with the indicated surgery. An atraumatic technic is imperative as local damage resulting from blunt dissection, violent retraction, forcible packing and ligation of veins close to their parent trunks may initiate the liberation of fibrin ferment into the blood stream and predispose to pulmonary thrombosis and embolism.

Hepatic Risk

Disorders of the liver are hazardous to the operative prognosis, owing to the danger of postoperative shock and the liability to acute hepatic failure. The latter condition is ushered in by a rapid rise in temperature and rapid pulse followed by uremic symptoms ending in coma and death. The definite cause of these so-called liver deaths is unknown but has been variously ascribed to the alteration in body chemistry incident to liver damage, as exemplified by the impairment of its deaminizing power; to a disturbance of the glycogen reserve, and to the reduced ability of the liver to detoxify histaminlike substances resulting from trauma (31, 30, 13, 18, 27, 28, 33, 32).

Unfortunately, preoperative evaluation of liver damage cannot be accurately gauged because of the following factors. (1) In spite of a vast amount of long and patient research devoted to the function of the liver, there is not as yet a clear understanding of its mechanism in the formation of bile, fibrinogen, and glycogen, its excretion of bilirubin, and its detoxifying power. (2) As pointed out by Snell and Magath (73), the reserve power of the liver is so great that functional abnormalities cannot be expected to appear until most of the organ has been destroyed. (3) The activities of the liver are so diverse that no single test can adequately estimate the amount of possible impairment. These difficulties naturally call in question the reliability of the various tests for liver efficiency, and at present there is no available method for an accurate prediction of the degree of potential damage or the likelihood of postoperative hemorrhage. Nevertheless laboratory tests should not be omitted, since, in conjunction with the clinical findings, they do furnish some criteria for the evaluation of the surgical risk. Ivy (41) asserts "I should never operate without performing beforehand an hippuric acid test or bromsulphalein or galactose liver function test, and

determining the bleeding time and coagulation time of the blood, except when emergency is definitely indicated"

In order to determine the degree of liver damage, information is sought in regard to the metabolic and excretory functions of the organ Snell and Magath (73) give an excellent summary of the possible methods and the reader is referred to their article for details Briefly, the investigation is concerned with the following.

(1) *Serum Bilirubin* An estimate of the amount of bilirubin present in the blood serum is, according to Judd, Snell, and Hoerner (47), the most important single factor in the evaluation of the status of the liver Normally the amount varies from 0.1 to 2 mg per 100 cc Higher levels signify a disturbance of bile metabolism The level is determined by means of the van den Bergh test and the icterus index The latter is obtained by a comparison of the color with that of a standard aqueous potassium bichromate solution The normal range is between 4 and 6 (2) *Protein Metabolism* Snell and Magath assert that "so far as tests of liver function calculated to test the protein metabolism are concerned, little has been done which is clinically significant" They also state in regard to (3) *Carbohydrate metabolism* that "If the capacity of the liver to maintain the normal amount of blood sugar is one of the most important functions of this organ, it is perhaps to be expected that this function would be conserved to the very end in the presence of disease of the liver This seems to be the case and for this reason functional tests of carbohydrate metabolism have been disappointing in practice" Thus, the various levulose and galactose tolerance tests proposed for the estimation of the glycogen function of the liver are of limited value (4) *Urobilin and Urobilinogen* Normally the bilirubin discharged into the intestine is reabsorbed to form pigment A damaged liver, however, is unable to resynthetize the urobilinogen, and hence it is excreted with the urine

(5) *Excretory Function* Many dyes have been used to test the excretory function of the liver The Rose Bengal and Rosenthal bromsulfalein tests are the ones most commonly employed These tests depend on the capacity of the liver to excrete the dye introduced into the circulation In the bromsulfalein test 1 cc of a 5 per cent solution of the dye for each 10 kilograms of body weight is introduced intravenously Normally, 85 per cent of the dye will be excreted within 1 hour Any retention above this quantity points to hepatic damage

(6) *Coagulation Factors* Tests for the determination of coagulation time cannot be depended upon to prognosticate the bleeding tendency, since no agreement has been reached as to the actual cause of the condition Research on the subjects of fibrinogen, prothrombin, calcium, and the sedimentation rate has failed to explain why individuals suffering from liver disease are subject to hemorrhage It not infrequently happens that patients with a prolonged coagulation time withstand operation well, whereas others whose coagulation time is normal succumb to fatal hemorrhage Ivy (42) attributes the bleeding to a deficient capillary tonus and believes that if this tonus can be eliminated, bleeding tests will then disclose any latent tendency to hemorrhage He eliminates the capillary tonus by the application of a sphygmomanometer cuff raised to a pressure of 40 mm of mercury, and after maintaining it for one minute at this level he tests the coagulation time by making a 2 5 mm puncture in the forearm with a mechanical stylet The normal limits of bleeding time as recorded in this test are between 180 and 240 seconds Any prolongation of the period beyond 240 seconds

indicates a latent tendency to hemorrhage Lewisohn (51) determines the bleeding tendency by multiplying the amount of prothrombin by the fibrinogen and dividing the product by the antithrombin. He believes that an index below 0 7 indicates a predisposition to hemorrhage. Snell and Magath conclude 'Any patient who has an injured liver parenchyma may bleed in spite of normal results of any existing test for coagulating factors, the greater the degree of hepatic insufficiency, the greater the danger of hemorrhage, high values for bilirubin in cases of icterus and high grades of retention of bromsulphalein in cases in which there is no icterus are danger signals and furnish information which is as reliable as that furnished by any current method of studying coagulation of blood"

(7) *Tests for Determination of Detoxifying Functions of Liver* The most common test is based on the capacity of the liver to conjugate benzoic acid and amino-acetic acid to form hippuric acid. The hippuric acid synthesis test as described by Quick (67) is as follows The patient is given 6 grams of benzoic acid, and its excretion in the urine is measured. Normally over 3 grams are discharged within 5 hours

Other tests to evaluate the status of the liver are those concerned with the (1) *Determination of Elimination of Bile Salts*, (2) *Quantitative Estimation of Phosphotase*, (3) *Fat and Cholesterol Metabolism*, (4) *Fragility of Red Blood Cells*, and (5) *Albumin Globulin Relationship* The latter relationship is determined by means of the Takata Ara Test. In the case of hepatic lesions there is a reversal in the albumin-globulin ratio

Management

On the assumption that liver damage is the basic cause of the hemorrhagic tendency operation should be postponed if possible until hepatic function has been restored as near to normal as possible. The patient should be confined to bed for a week or two prior to operation. The daily urinary output should be maintained at 1,500 cc. in order to protect the kidneys against damage resulting from the faulty metabolic products they are forced to excrete (p 339) To assure such an output the patient should be encouraged to partake freely of fluids. If a sufficient quantity cannot be taken orally, recourse must be had to intravenous injections of glucose solution (p 350) The bowels are regulated by the administration of aromatic fluid extract of cascara sagrada in doses of between 4 and 15 cc.

Diet. The functional efficiency of the liver can be largely increased and the hepatic risk minimized by the ingestion of large quantities of carbohydrates and a limitation in the consumption of proteins and fats to the amount necessary for basal requirements The carbohydrates stimulate regeneration of liver cells, act as an antidote to many toxins, including the anesthetic, and lessen the tendency to bleeding A daily intake of 5 to 8 grams per kilogram of body weight is usually sufficient and may be given in the form of lactose in drinks, honey on bread, potatoes, cereals jellies, gruels fruit juices, syrups, etc. If the patient cannot take the required amount orally, it may be administered intravenously as a 10 per cent solution of glucose Care should be taken however, not to prescribe too great a quantity of carbohydrates otherwise the increase in blood-sugar may exceed the renal threshold and give rise to glycosuria. While a normal person can metabolize 1 gram of glucose per hour for each kilogram of body weight and does not present evidence of glycosuria until the level of blood-sugar reaches 160 to

170 mg per cent, in the case of patients with liver disease not more than 0 3 to 0 4 gram of glucose per kilogram of body weight can be metabolized in the same period, and glycosuria begins at a lower blood-sugar level For the same reason, if insulin is required for a hepatic patient, a relatively small dose should be used, since an amount insufficient to produce hypoglycemia in the absence of liver damage, may in its presence lead to hypoglycemic shock In view of the fact that the liver functions in the deamination of amino-acids, the destruction of uric acid, and the synthesis of urea, it seems reasonable that the protein intake should be restricted in order not to put an additional load on an already embarrassed organ Naffziger (59) suggests that a minimum maintenance diet of protein lessens the tendency to bleeding by reducing the organic sulphur compounds, which he believes to be anticoagulants

On the grounds that Vitamins A, D, and C are factors in the control of the blood calcium level, and deficiency of these vitamins may aggravate the tendency to bleeding, their administration has been suggested Fantus (20) writes "Because along with the failure of adequate fat digestion there no doubt goes inadequate absorption of vitamins A and D, it is claimed, though not proved, that lack of vitamin D, which makes calcium available for the body's use, may in part be responsible for the bleeding tendency of jaundiced patients Solution of Irradiated Ergosterol (Viosterol) may therefore be given with possible advantage in 2 cc doses three times a day, two hours after meals and accompanied by 0.5 gm doses of Extract of Ox Bile, best administered in double gelatin capsules to produce duodenal action so far as possible It will be noted from the detailed dietary that administration of fruit juice is stressed because vitamin C deficiency is particularly prone to produce a tendency to capillary fragility. Whenever achlorhydria is present—and it may be in jaundice—vitamin C is so extensively destroyed in the alimentary tract before it can be absorbed that parenteral administration of cevitamic acid is indicated and a daily dose of 0 6 gm should be aimed at until the urinary saturation test shows that the systemic deficiency has been overcome " Butt, Snell, and Osterberg (9) suggest the use of Vitamin K on the basis of their observation that the administration of this vitamin in conjunction with bile salts had an inhibitory effect on bleeding

The benefits to be derived from *calcium salts* for the control of hemorrhage are the subject of considerable difference of opinion Linton, Kirk, King, and Zimmermann have shown that hemorrhage is not associated with a diminution in the available calcium in the blood, and have also demonstrated that the amount of blood calcium bears no relation to the bleeding or clotting time On the other hand, there are sufficient proofs to indicate that calcium does protect the tissues against the effects of bilirubin and abnormal liver products (49) On the basis of this evidence and in view of the fact that their administration occasions no harm, calcium salts should be given preoperatively until the blood shows a calcium content of between 9 and 11 mg per 100 cc They may be prescribed in the form of skimmed milk added to the diet, or as calcium lactate, calcium phosphate, or calcium gluconate in teaspoonful doses 3 times daily for several days prior to operation The latter may also be given intravenously in 20-cc doses of a 5 per cent solution at 4- to 6-hour intervals Walters advocates a daily intravenous injection, for three days prior to operation, of 5 cc of a 10 per cent solution of calcium chlorid dissolved in 100 cc of physiologic salt solution Judd (46) advised parathyroid extract in doses of 0 003 gram ($\frac{1}{20}$ grain) in conjunction with calcium salts

Fantus (20) describes a test for the determination of the potential value of calcium in increasing the coagulability of the blood. "Withdraw 2 cc. of blood by venipuncture. Set 1 cc. to coagulate spontaneously To the other cubic centimeter add six drops of 0.5 per cent solution of calcium chloride. Determine the coagulation time of both specimens If the calcium containing specimen coagulates more rapidly, calcium is indicated, otherwise it is not."

Blood Transfusion. Blood transfusion is the most valuable single measure for the protection of a patient with a damaged liver (46) The reduced oxygen saturation of the blood, which is said to occur in hepatic diseases, has a deleterious effect on the liver cells, and the blood transfusion serves to furnish the necessary oxygen. Two or 3 transfusions of 250 to 300 cc. should be given as a routine measure at 48-hour intervals prior to operation and 500 cc. following operation

Irradiation of the spleen has also been suggested as a prophylactic procedure for the control of hemorrhage When resorted to it is given in ½ erythema doses over the splenic area 4 hours before operation.

As regards the anesthetic agent, it is hardly necessary to say that the choice should fall on one which does not depend on the liver for detoxification and which will cause the least damage to the hepatic cells. Obviously then, the use of ether is contraindicated (68) (p 429) Gas-oxygen in conjunction with a local agent is preferable.

Diabetic Risk

The diabetic patient has always presented an intricate surgical problem Due to the hyperglycemia and the frequently associated arteriosclerosis, healing is delayed, wounds have a tendency to slough, and infection and gangrene are likely to supervene after operation. Metabolism is in a precarious state, and slight operative trauma, infection, or the effects of the anesthetic agent may be sufficient to cause a further disturbance of the process with a breaking down of the acid base equilibrium followed by coma and possibly death

The operative risk has been much reduced since the discovery of insulin by Banting in 1922 and the more recent use of protamin zinc insulin. As a matter of fact, it often happens that diabetic patients, due to their more careful preoperative treatment and supervision, fare as well as the non-diabetic. Foster (26) has pointed out that the death rate from infection in diabetes has been lowered by means of insulin from 40 to 25 per cent. The recognition of the importance of water balance and the development of anesthesia have also played an important part in the reduction of diabetic mortality Today the presence of this disease need not interdict an indicated operation, provided the condition is recognized and treated early and adequately With modern methods even severe cases of acidosis may be brought under control within a very few hours. If, however, the disease is of more than 5 years' duration, there is a probability of arteriosclerosis with its associated danger of gangrene and coronary disease. This imposes an additional hazard and must be taken into consideration in the evaluation of the risk involved (45, 60 18) In order to obtain the best results, an internist should be called upon to direct the medical and dietary measures before and after operation. It has been largely due to such co-operation that the mortality in these cases has been reduced during recent years.

Management

Preoperative. In the case of elective operations a well-nourished and adequately managed diabetic patient requires no special preoperative care other than that entailed in the elimination of sugar from the urine and the reduction of blood-sugar to normal Forced feeding or the administration of intravenous dextrose is unnecessary A weakened, undernourished patient, however, demands special preparation He should be placed on a maintenance diet and be given sufficient insulin to control carbohydrate metabolism This diet should include a daily intake of at least 100 grams of carbohydrate, in order to maintain the necessary glycogen reserve of the liver This may be furnished in the form of orange juice, strained cereal, honey, ginger ale, etc The customary daily prescription of insulin is between 10 and 20 units, occasionally 30 units may be necessary, but it is better to give too little rather than too much, so as to avoid the possibility of hypoglycemic shock Standard, Brandaleone, and Ralli (74) advise "a high carbohydrate, limited fat diet When the operation is one of choice the patient is kept on such a diet, usually from 180 to 250 grams of carbohydrate, from 70 to 80 grams of protein and from 75 to 85 grams of fat, for several days before operation Enough insulin is given before meals to keep the patient sugar free on such a diet " The ideal time for operation is when the amount of blood-sugar is between 140 and 170 mg per 100 cc , the carbon dioxid-combining power normal, the urine free from sugar and ketone bodies, and there is no evidence of dehydration

Three hours before the time scheduled for operation the patient is fortified by means of the oral administration of carbohydrates in the form of glucose The quantity varies with different clinicians Some allow an amount equal to ¼ the total daily ration, together with ¼ the total daily insulin dose Others prefer to give ½ the amount of carbohydrate usually allotted for breakfast and ½ the patient's customary dose of insulin Still others prescribe a routine administration of 200 cc of orange juice and 10 units of insulin The carbohydrate may also be given intravenously Ordinarily, 50 grams of glucose in a 10 per cent solution controlled by the usual dose of insulin are sufficient If, however, the patient has not been previously treated with insulin, it should not be administered at this time, since its use may lead to hypoglycemic shock during the period of anesthesia Greater quantities of glucose than those mentioned above are unnecessary and may be harmful, as there is little likelihood that they would increase the glycogen reserve, and they might suddenly flood the body with carbohydrates at a time when additional amounts of glycogen are being discharged from the liver due to emotional strain Conversely, fasting before operation should not be permitted, since a lack of carbohydrates will cause an incomplete combustion of fats, release acids, and induce acidosis Bannick, Gregg, and Guernsey (2) employ the following treatment immediately preceding the operation "For all but minor surgical procedures an infusion of 1,000 cc of physiologic solution of sodium chloride with 50 gm of dextrose given two hours before the operation is quite satisfactory For minor operations 300 cc of orange juice is given by mouth 1½ hours before the operation A guide based on the urinalysis is used to estimate the amount of insulin required with the infusion or orange juice " They base the dosage of insulin on the following table

"*Urinalysis*	*No Sugar*	*Sugar*	*Sugar and Acetone*
Carbohydrate	50 gm	50 gm	50 gm
Fluid	1,000 cc of physiologic solution of sodium chlorid		
Insulin units	10–15	20–30	30–40"

In the case of operations of an emergency nature in diabetic patients, an immediate determination of the blood-sugar and the carbon dioxid-combining power of the plasma should be made, followed by a urinalysis, insulin should be withheld until the status of the carbohydrate metabolism is established. When insulin is indicated in these cases, the initial dose should not exceed 15 units, in order to avoid insulin shock. Subsequent doses must be governed by the patient s individual reaction

If he exhibits symptoms of impending acidosis, as indicated by the presence of acetone and diacetic acid in the urine, acetone odor on the breath, polypnea, and a lowered carbon dioxid-combining power, vigorous treatment should be instituted at once The therapy to be adopted will depend upon the degree of glycosuria, the extent of acidosis, and the patient's reaction to insulin. Except in those cases where the urine contains more than 0.5 per cent of sugar glucose controlled by insulin should be administered. If the acidosis has progressed to the point of coma, 20 units of insulin are given subcutaneously and 20 units intravenously at the same time This dose should be followed within 2 hours by another subcutaneous dose of 10 to 20 units, repeated at 2 hour intervals if necessary As recovery from the coma takes place, the dose is diminished and the interval between administrations lengthened. To increase the alkali reserve, 50 grams of sodium bicarbonate, administered preferably by mouth or intravenously, in a 5 per cent solution, are usually sufficient.

Diabetic patients showing evidence of dehydration should receive infusions of normal salt or glucose solution. Frequently from 5 000 to 7,000 cc. are required (p 343) The presence of infection in a diabetic patient is particularly hazardous, as it not only aggravates the disease but also lowers the efficiency of insulin. If the operative indication is a local infection, some surgeons prefer to operate at once, without waiting for the stabilization of the patient, assuming that adequate drainage relieves the hyperglycemia and renders the diabetes more amenable to treatment. On the other hand, others are opposed to immediate surgical intervention and strive to obtain a preliminary stabilization

Operative The choice of the anesthetic agent, the skill exercised in its administration, and the duration of the period of anesthesia are all factors of the utmost importance. The agent must be one which will interfere least with carbohydrate metabolism For this reason local anesthesia is preferable either by infiltration, nerve-blocking, or spinal analgesia. In the event that local infiltration is the method chosen, caution must be taken, since the malnutrition of the tissues may lead to suppuration and gangrene If a general anesthetic is indicated, ethylene-oxygen or nitrous oxid and oxygen are the most desirable agents. Of these the former is preferable as it produces less alteration in carbohydrate metabolism and a lesser degree of anoxemia. Neff and Stiles (61) point out the value of cyclopropane anesthesia in diabetic surgery They claim that this agent causes a rise in blood-sugar of only 7 mg per cent and a decrease in the carbon dioxid-combining power of the plasma of less than 2 volumes per cent. Ether and chloroform are ordinarily best avoided as they predispose to hyperglycemia, depress the glycogen reserve of the liver, retard the excretion of ketone bodies, disturb respiration and give rise to postoperative nausea, vomiting and loss of appetite—all of which factors lead to acidosis.

The operation should be performed as gently and as quickly as possible, and all exposed tissue should be kept warm Before the patient leaves the operating room he should be given an intravenous or subcutaneous infusion of 1 liter of normal saline

solution containing 25 grams of glucose controlled by insulin, the quantity being based on his known tolerance

Postoperative. Following operation the patient is returned to his usual dietary regimen and insulin ration as soon as possible, in order to prevent hyperglycemia and its attendant acidosis Three hours after operation the blood is examined for an estimation of the sugar content and the carbon dioxid-combining power of the plasma, and the urine is investigated for the detection of ketone bodies These tests are of value in determining the presence of acidosis and in measuring the insulin requirement Although no general rule can be formulated as to the postoperative insulin dose, it ordinarily ranges between 5 and 15 units In the absence of acidosis a safe rule to follow is the prescription of the amount of carbohydrate and insulin which the patient is accustomed to take for breakfast If for any reason patients are unable to take carbohydrates by mouth, 50 grams of glucose in a liter of normal salt solution may be introduced intravenously The quantity of fluids to be administered must be guided by the patient's general condition, but in all cases the intake must be sufficient to permit of the excretion of at least 1,500 cc of urine

Twenty-four hours after operation the patient is placed on a liquid diet which is gradually replaced by semisolid and finally solid food The amount and proportions are regulated by daily chemistry studies which are to be continued until the patient's metabolism becomes stabilized Bannick (2) advises that as soon as the patient can take food by mouth he be fed at 4-hour intervals, and that the feeding include from 25 to 50 grams of carbohydrates In the course of 4 to 6 days he is returned to a semisolid diet and allowed from 4 to 5 daily feedings, and within 10 days the number of meals are reduced to 3 Insulin is given before the feedings in amounts sufficient to keep the urine free from sugar

Except for the observance of the above dietary measures the postoperative treatment is similar to that given to non-diabetics The use of strong antiseptics, however, should be avoided, heat should be applied with extreme caution, as the skin has a tendency to burn, and morphin should be used sparingly since these patients have a diminished tolerance to the drug Moreover, their proneness to infection necessitates daily examination of the wound for the evacuation of any possible hematoma that may have formed

Thyroid Risk

The condition of the thyroid gland should be carefully investigated before any operation is undertaken, since a disturbance of this gland affects the basal metabolism, lowers the resistance to infection, and favors acidosis In patients suffering from toxic goiter the associated cardiovascular lesions present additional hazards Even in uncomplicated cases many treacherous possibilities lurk in the background, and among these is the so-called "thyroid crisis," characterized by restlessness, vomiting, diarrhea, rise in temperature, and increased pulse rate and respiration, followed by delirium and possibly coma and death The risk incurred by operation in these instances can be greatly reduced by a careful selection of the patient, a due regard to the appropriate time for operation, preliminary medication, and a meticulous choice of the anesthetic agent, all of which factors require the closest co-operation between surgeon and internist

The patient should be hospitalized for at least 2 weeks prior to operation to permit of ample time for proper investigation and for bringing the body chemistry to an optimum During this preoperative period all septic foci should be eradicated and the nutrition improved. Since these patients are usually undernourished and have a high metabolic rate, their food intake should amount to 5,000 or 6,000 calories daily If the basal metabolism is above 50 per cent of normal, iodin is administered by mouth in the form of Lugol s solution 0.3 to 0 6 gram (5 to 10 drops) 3 times a day The pulse rate is reduced by the use of digitalis and marked restlessness is controlled by sedation with barbiturates.

The choice and dosage of the anesthetic agent require careful study especially in the case of patients suffering from hyperthyroidism As they are particularly prone to emotional upsets, basal premedication is indicated to allay their apprehensions (p 399) For the same reason general anesthesia is preferable to regional. Of the general anesthetics cyclopropane is the most suitable, as it can be administered in combination with large quantities of oxygen. Ether is to be avoided, since it may aggravate the liver damage which so frequently accompanies this disease

Preoperative Routine

The estimation of the patient's capacity to withstand operation and the control of the adverse factors affecting the outcome having been disposed of, it now remains merely to discuss the immediate preoperative routine care from the beginning of the hospitalization period up to the hour set for operation. Fortunately, the elaborate and often harmful measures of the past have been replaced within the last 2 decades by a simpler, more physiologic management which has been amply justified by the greater percentage of uncomplicated recoveries. While the details will naturally vary widely in accordance with the circumstances, the aim in all cases is to bring the patient's body chemistry to an optimum, so that he may best resist the disturbance occasioned by the operative trauma and the anesthetic agent.

A patient regarded as a good operative risk should be hospitalized for at least 36 to 48 hours before the time scheduled for operation. The preoperative stay allows time for the proper examinations to determine his fitness for operation and, if necessary, for the correction of minor local or constitutional disorders. Frequently such examinations reveal new aspects which may have an adverse influence on the operative outcome. During this period the patient is also afforded the opportunity of becoming accustomed to confinement in bed and of adapting himself to his new environment. Patients classed as fair or poor risks necessarily require a more prolonged preoperative hospitalization When circumstances allow it is advisable that they vacation in the country or at the seashore for several weeks previously Eccles (15) is of the opinion that "if the patient can be sent to a congenial health resort, possibly away from over anxious relatives, and have quiet, rest, good sleep in fresh air and real encouragement, marked improvement in all round 'tone soon occurs, appetite returns, assimilation of food is good, anemia vanishes, and a mental and bodily vigor sometimes quite astonishing returns, the sufferer being fitter to undergo what is to him, a real ordeal. If possible, the time for operation should be planned to suit the patient's convenience. Where circumstances permit consideration should be given to seasonal variations. Summer is the ideal time for operation, during the winter indoor confinement and lack of sunshine

lower the "general resistance" and predispose to respiratory complications. The choice of hospital should be governed by the patient's financial condition, but considerations of economy should not be allowed to stand in the way of adequate equipment and a carefully trained personnel, since this not only would place the surgeon at an unnecessary disadvantage but would also react to the patient's detriment. The ideal hours for operation are during the early morning when the patient's resistance is at an optimum, his stomach is empty, and he has not had time to brood over the impending procedure. Moreover, should surgical complications develop, assistance is more readily available at this time than during the night.

Preoperative measures should be instituted directly upon the patient's admission to the hospital and should be carried out in a tactful and orderly manner. He is placed at once under conditions conducive to mental and physical composure, given a bath, encouraged to use a toothbrush, and put to bed in a pleasant, quiet, airy room. As soon as he has been made comfortable, he is visited by the house surgeon who, having notified the attending surgeon of the patient's arrival and received orders for his immediate care, elicits a detailed and careful history, conducts a physical examination, and prescribes routine laboratory tests. The attending surgeon arrives as soon as convenient, makes whatever further examinations are deemed advisable, and confirms the previous diagnosis. He explains to the patient the nature of the contemplated operation, the type of anesthesia to be used, and the probable length of stay in the hospital. Before his departure he obtains the patient's written consent to operation and leaves orders regarding diet, medication, and special laboratory procedures, when indicated. Once the diagnosis has been made, pain, if present, should be alleviated, as it is exhausting and predisposes to shock. Those in charge should make every attempt to assuage the patient's fear. The change of apparel, the strange surroundings, and the operative preparation which the hospital personnel view with a detached mind often take on terrifying proportions in the eyes of the patient. Courtesy, consideration, and sympathy will do much to engender confidence. Injudicious conversation pertaining to the operation should be interdicted, and any collateral influences, such as family worries and anxieties, bearing upon the patient's mental outlook eliminated. Visiting hours should be limited to one or two short periods and depressing visitors excluded.

Diet

Obviously the nutritional management of patients about to undergo operation is of the utmost importance. Failure to take this factor into consideration is often responsible for delayed healing and slow convalescence. The former routine procedure of preoperative starvation has fortunately been abandoned since it was found to predispose to acidosis and to lead to dehydration. Starvation not only rapidly exhausts the glycogen reserve of the liver, but also delays the absorption of carbohydrates during the postoperative period. Ross and McKenzie have shown that after 24 hours of starvation 2.66 grams of carbohydrates per kilogram of body weight is absorbed hourly, and after 48 hours only 1.78 grams per kilogram of body weight. With a deficiency of carbohydrates in the circulation the oxidation of fats, which depends upon a normal carbohydrate content, is incomplete. This deficiency leads to the formation of oxybutyric acid, diacetic acid, and acetone, which precipitates acidosis

Several days prior to operation the patient is placed on a well-regulated dietary regimen. While each individual presents his own particular problem, yet, broadly speaking, if he is in good general health, all that is necessary is that the diet be plentiful, easily digestible, of a high carbohydrate and low fat and protein content, and of such a character as to leave little residue, so that the alimentary tract can be readily emptied. Any appreciable deviation from the patient's customary diet should be avoided, as it tends to produce metabolic disturbances, especially in those of nervous temperament. Individual tastes and idiosyncrasies should be taken into account. Stimulants, such as alcohol, tea, and coffee, should not be suddenly withheld from those addicted to their use as they may be of value in tiding such individuals over a critical period.

The amount and proportions of the various food elements must receive careful consideration, in order that the patient's normal weight and strength may be maintained and constipation prevented. To supply the required number of calories and at the same time avoid a diet which is either so bulky or so concentrated as to upset the alimentary apparatus demands careful judgment. Physiologists estimate that 25 calories per kilogram of body weight are needed to maintain basal metabolism Thus, for a person weighing 75 kilograms the minimum daily requirement is 1,875 calories. Despite the fact that the surgical patient is confined to bed the impending operation makes it necessary to increase the caloric intake well above his basal needs. If the metabolism is abnormally high, this must be compensated for by the prescription of an even greater caloric intake, if the tissues are to be conserved. Average adult patients weighing 75 kilograms should be supplied daily with 2,500 to 3,000 calories, given in such proportions as to maintain the chemical balance of the tissues and to permit of complete oxidation of the ingested fats. The correct proportion is estimated to be proteins 100 grams, furnishing approximately 400 calories, fat 50 grams, furnishing 450 calories, and carbohydrates 500 grams, furnishing 2,000 calories (25)

Carbohydrates. Since all patients are subject to some degree of liver damage vomiting, acidosis, and dehydration in the postoperative period, the preoperative diet should be so planned as to counteract these tendencies. This is best accomplished by the administration of liberal quantities of sugar and fluids. Carbohydrates may be given in the form of candy glucose, fruit drinks, corn syrup or honey on bread, etc. Bridges (5) requires that the patient "ingest ½ pound of hard candy or soft gum drops on each of the 5 preparatory days." If carbohydrates cannot be tolerated by mouth, they may be introduced parenterally by slow intravenous drip as a 5 to 10 per cent glucose solution in the proportion of 10 to 20 cc. per kilogram of body weight (p 350) Where shock is anticipated, Fisher recommends an intravenous injection of 500 to 2 000 cc. of a 10 per cent solution of glucose, to each 3 grams of which has been added 1 unit of insulin, ½ the total amount of insulin being given 15 minutes before the injection and the balance at its completion.

All patients are encouraged to drink water freely, since it will not only help to prevent postoperative dehydration, but also by its diuretic effect will aid in the elimination of the anesthetic. If fluid cannot be administered orally, it is given parenterally The importance of the prescription of an adequate fluid intake as a preoperative measure is discussed in detail on page 338. Fantus (19) states "Excepting in emergency, hypohydrated and salt starved patients must not be sent to operating rooms. If there

is a standing order that no patient should be sent to the operating room unless he has passed at least 1500 cc of urine in the preceding 24 hours and this urine contained at least 0 5 per cent of chloride this requirement would be automatically met "

Proteins Sufficient protein must be included in the preoperative diet to maintain the nitrogenous balance This is equivalent to 1 gram of protein per kilogram of body weight

It is also believed by some clinicians that certain amino-acids produced in protein metabolism are necessary to the formation of the various hormones A deficiency of proteins leads to a decrease in gastro-intestinal secretion, to edema, dry skin, icterus, weakness, loss of weight, and mental stupor Unlike carbohydrates and fats, proteins cannot be built up from other food elements and must be supplied as such

Mineral Elements. For the maintenance of the chemical balance, 12 to 15 grams of sodium chlorid, 0 88 gram of phosphorus, and 0 45 gram of calcium should be included in the daily diet

Vitamins. The value of vitamins in the diet is difficult to assess clinically It is generally believed, however, that an adequate intake of vitamins is essential to optimal nutrition (34), and therefore their administration should be included in the regular routine of the preoperative preparation Vitamin A is believed to be necessary for the proper functioning of the epithelial cells Experimental evidence shows that a deficiency of this element predisposes to bacterial invasion and delays wound healing by an interference with the integrity of these cells The vitamin may be furnished in the form of certain animal foods, notably liver, milk, butter, cheese, and egg yolk, and in the guise of carotin found in yellow and green fruits and vegetables It may also be supplied as Vitamin A concentrate, the usual requirement being between 10,000 and 20,000 international units daily Vitamin D regulates calcium and phosphorus metabolism and should be given either in the form of cod liver oil or as a concentrate of 1,400 international units daily Vitamins B_1, B_2, and the complex B_2 and B_6, known as Vitamin G (riboflavin), are said to increase the appetite and promote the healing of wounds They are found in spinach, eggs, yeast, cabbage, milk, etc , or may be prescribed in concentrated form in doses of 300 to 400 international units daily Vitamin C is believed to control the nutrition of the endothelial lining of the capillaries and to accelerate the coagulation of the blood, and on this assumption it is advocated in cases of hemorrhagic diatheses It may be supplied in the form of lemon juice or orange juice sweetened with glucose, or given as a concentrate in doses of 600 to 1,200 international units

In the *Journal of the American Medical Association* for April 15, 1938, in answer to a query as to the proper dosage of vitamins, there occurs the following statement: "There is available a variety of commercial preparations which supply vitamin A in concentrated form The Council on Pharmacy and Chemistry has accepted a number of brands of cod liver oil concentrate dispensed either in liquid (bottled or in capsules) or in tablet form, as well as a solution of pure carotene in cottonseed oil The cod liver oil concentrate capsules supply approximately 10,000 international units of vitamin A and 1,400 units of vitamin D per capsule The cod liver oil concentrate tablets supply approximately 3,000 U S P units of vitamin A and 300 international units of vitamin D per tablet, while the solution of carotene in oil provides not less than 7,500 units of vitamin A per gram, with no vitamin D The Council has also accepted several brands

of halibut liver oil marketed either in liquid form or in capsules which provide approximately 10,000 international units of vitamin A and 170 international units of vitamin D per capsule. Concentrated sources of vitamin B_1 are dried brewers' yeast and wheat germ, a number of brands of which have been accepted by the Council on Foods. Quantitative data regarding the vitamin content of a large number of common foods may be found in the recently published U S Department of Agriculture Miscellaneous Publication 275, entitled 'The Vitamin Content of Foods, by Esther Peterson Daniell and Hazel P Munsell."

In addition to supplying the caloric, mineral, and vitamin needs, it is essential that the food be diversified, well cooked, properly seasoned, and served in an attractive manner, since dormant appetites are frequently stimulated by tempting food.

The routine hospital diet is maintained up to the evening preceding operation. If a general anesthetic is to be used, the evening meal before operation should be light, and all foods except water prohibited after 6 P.M On the morning of the operation, should the patient so desire, he may be given an 'ether breakfast" consisting of a cup of black coffee with sugar If the operation is scheduled for late in the afternoon, he is allowed a cup of coffee or tea with sugar and a slice or two of buttered toast 3 hours before operation.

Elimination

Obviously it is desirable that the alimentary canal be reasonably empty at the time of operation. This will add materially to the patient's comfort. However the administration of drastic aperients preoperatively is unnecessary and undesirable as these agents tend to irritate the colon, upset the fluid balance by causing diarrhea, interfere with sleep, and send the patient to the operating theater in an exhausted and dehydrated state. In addition they increase the tendency to postoperative nausea, vomiting, and flatulence. If the bowels have moved on the day before operation, no further interference is necessary In those cases where they have not moved for 2 to 3 days a gentle laxative, such as mineral oil, is advisable, and this should be given in a dose small enough not to disturb sleep Children may be given syrup of figs or similar preparations. If an enema is indicated, it should be administered not later than 2 hours before operation, otherwise, it may result in the soiling of the operating table. Salt solution is preferable to soapsuds, as it is less irritating

Local Preparation

The operative site is prepared on the night preceding operation. While the details vary according to the part of the body involved, the steps are essentially as follows The area is shaved with a sharp razor, care being taken not to abrade the skin. It is then gently scrubbed with green soap and warm water for 5 to 10 minutes, the procedure being interrupted at frequent intervals by douching with sterile water (p 5) The fatty material is dissolved out with some lipolytic agent, such as alcohol, ether, or benzene. The parts are then dried, and if the location of the site permits, a sterile dry dressing is applied and left undisturbed until the patient is on the table and ready for operation. Moist antiseptic compresses are to be avoided, as they have a tendency to macerate the skin.

A good night's rest is an important adjuvant in overcoming the strain imposed by the operation If the strange surroundings and apprehension interfere with the patient's sleep, a hypnotic should be administered to relieve the devastating effects of fear on the nervous system The nature of the sedative and the dosage will naturally depend on the temperament of the individual (p. 396) The most efficacious agents are luminal 0 06 to 0 13 gram (1 to 2 grains), amytol 0 1 gram (1 5 grains), sodium amytol 0 2 gram (3 grains), and nembutal 0 1 gram (1 5 grains) If the insomnia is due to pain, morphin 0 016 gram ($\frac{1}{4}$ grain) or omnopon 0 02 gram ($\frac{1}{3}$ grain) is substituted Children usually sleep well, but if they are restless, chloral hydrate 0 065 gram (1 grain) for each year of life may be given The use of sedatives on the morning of operation will also do much to relieve anxiety and prevent shock Such drugs facilitate the induction of general anesthesia and, in case a local anesthetic is used, render the patient indifferent to the surgical procedure A hypodermic injection of morphin in combination with atropin is ordinarily employed a half hour before operation—morphin 0 01 gram ($\frac{1}{6}$ grain), and atropin 0 0006 gram ($\frac{1}{100}$ grain) The former allays fear and the latter acts not only as an antidote to the depressing effect of the morphin on the respiratory center, but also checks mucous secretions For certain patients of markedly nervous temperament a basal anesthetic may prove of advantage With the use of this agent it is possible to perform the operation without the patient's realization of the fact that he has left his room While basal anesthetics serve excellently in well-selected cases, their administration is associated with some danger in the presence of cardiorenal and liver disease, and in elderly individuals For a detailed discussion of their application the reader is referred to Chapter VII

Just before the patient is transported to the operating room, he is requested to empty his bladder, and the amount voided is noted on the chart He is clothed in a suit of warm pajamas, buttoned up the back to facilitate its adjustment or removal during and after the operation Infants are kept warm by means of cotton wool wrapped loosely around the body If the patient's hair is long, it is parted in the middle and arranged in two braids, in operations on the head and neck it is thus kept out of the way and following operation it permits the head to rest more comfortably Artificial teeth are removed and care is taken that no foreign body, such as chewing gum or tobacco, is retained in the mouth

At the appointed hour the patient is taken to the anesthetizing room Transportation should be effected without confusion Conversation and comments on the operation are interdicted and the presence of relatives forbidden The room should be quiet, shaded, and so situated as to eliminate disturbances caused by the passing of doctors and nurses about their duties, and any noises incident to the preparation of the instruments

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CHAPTER IX

POSTOPERATIVE MANAGEMENT

The surgeon's responsibility does not end with the completion of the operation Indeed, the after-care is fully as important as the operation itself It includes a close scrutiny of the patient during the immediate postoperative period in the hospital, and after his discharge continued observation and recommendation until his physical well-being is restored and his mental equilibrium re-established

The need for after-care is usually in inverse proportion to the adequacy of the preoperative preparation and the quality of the work done at the time of operation With careful preparation and good surgery the majority of patients evince little inconvenience or discomfort while passing through the postoperative period The complicated and empiric postoperative treatment of the past has given way to a simpler management based on physiologic principles Careful nursing, rest, avoidance of excitement, attention to nutrition and elimination, and mental reassurance are ordinarily all that is required But, despite every care, serious complications necessitating prompt treatment may at any time arise and unless such treatment is given, a carefully planned and skilfully performed operation may be converted into a postoperative disaster Constant observation is therefore essential, and the most trivial deviation from the normal should be immediately investigated

Directly after the operation the patient is returned to his room and gently lifted into a warmed bed It is important that all hot-water bottles be removed beforehand, otherwise the patient, being in an unconscious or semiconscious state, is likely to be burned He is placed in as comfortable a position as is consistent with the circumstances A nurse remains in constant attendance until he recovers from the influence of the anesthetic If the operation was in the vicinity of the mouth or jaws, the foot of the bed should be elevated so as to assist bronchial drainage, and this elevation should be maintained for 3 or 4 days thereafter as a precaution against aspiration of infected oral secretions or blood If shock seems imminent it is likewise advisable to keep the head low, in order to minimize the danger of cerebral anemia It is essential that the patient be kept warm and shielded from drafts, although too many blankets or overheating of the room should be guarded against, as they cause undue sweating which may in turn lead to severe dehydration In order to facilitate breathing and to prevent the aspiration of mucus and vomitus the patient is turned slightly to one side with supporting pillows placed under the head and behind the shoulder The room should be kept darkened, quiet, and warm, and should be well ventilated for the elimination of the fumes of the exhaled anesthetic If carbon dioxid and oxygen are to be administered, it is important to see that the room be free of any form of open flame that might ignite the oxygen Should respiration become obstructed, the mouth is opened, the tongue drawn forward, and the pharynx cleared In the event of vomiting, the head is turned to one side over a basin and the jaw held forward; the

lips are wiped, the mouth cleansed, and soiled clothing removed, since the unpleasant odor in itself may provoke further vomiting The quantity of vomitus should be recorded, so that proper compensatory measures may be taken later in the establishment of the water balance (p 343)

Before the surgeon leaves the hospital, he visits the patient, satisfies himself as to his condition, and gives instructions for his care While visitors should be excluded for the first 48 hours, it may be expedient to admit the family for a view of the patient, so that they may be reassured of his survival of the ordeal. As soon as consciousness is regained, provided the general condition is satisfactory, the patient s head and shoulders are propped up by means of a bed rest to favor respiratory movements.

The immediate postoperative requirements are (1) good nursing, (2) rest, (3) relief of pain, and (4) maintenance of water balance.

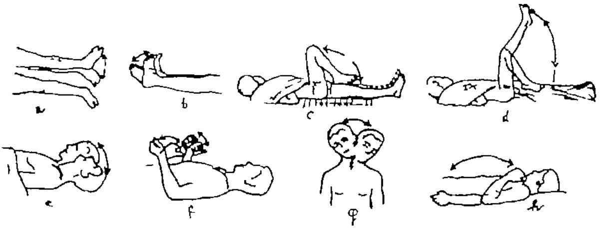

FIG 206. Convalescent exercises to favor circulation. (Pool)

Nursing

The nurse keeps a complete record of the patient's physical functions, and records the intake and output of body fluids She keeps a constant watch of the blood pressure pulse, respiration, and temperature, and notes the condition of the skin. Any departure from the normal is immediately reported to the surgeon in charge, so that prompt treatment may be instituted. An increasing pulse rate together with a falling temperature points to shock a rising pulse with an elevation of temperature is significant of infection a slowing pulse rate with a rise in temperature indicates absorption of traumatized tissue an increased respiratory rate raises the suspicion of pulmonary complications (p 508)

In order to add to the patient s comfort, diminish the risk of pulmonary complications and at the same time prevent parotiditis, special attention should be given to the care of the mouth The teeth are cleansed after every meal The tongue is wiped with linen moistened with glycerin and borax, and to promote the flow of saliva the patient is encouraged to suck acid drops or lemon candy

Rest

Physical rest is of paramount importance for a satisfactory convalescence and should include a period of hospitalization long enough for adequate surgical care. The

duration will depend on the age and general condition of the patient, the nature of the operation, and the location of the wound To insure sleep on the night following the operation, a sedative should be administered late in the afternoon In the absence of pain, allonal 0 13 gram (2 grains) may be used, but if pain is present, morphin must be resorted to To counteract the unfavorable effects of confinement in bed, the patient is encouraged to change his position frequently and flex and extend the legs Body movements help to inhibit venous stagnation and thus minimize the danger of thrombosis and embolism, they favor aeration of the lungs and lessen the likelihood of pulmonary complications, prevent abdominal distention, and assist in the maintenance of muscle tone (fig 206)

No set rules can be laid down as to the required period of rest in bed It will be governed by the preoperative condition of the patient, the character of the operation, and the presence or absence of complications In the case of the aged and individuals with poor circulation, it is sometimes advisable to get them out of bed as early as the third day following operation Homans (56) states that in his experience convalescence is accelerated when the individual is encouraged to get out of bed as early after operation as is expedient, if for only a few minutes each day During the interval between getting out of bed and his discharge the importance of the after-treatment should be impressed upon the patient and minute instructions given him as to how it should be carried out If after leaving the hospital he is in need of further care details of the required after-treatment are sent to his physician

Relief of Pain

A certain amount of pain and discomfort is to be expected after all operative procedures, the degree depending upon the individual susceptibility of the patient and the nature of the operation Relief of pain is imperative, for, unless controlled, it interferes with sleep, inhibits respiratory movements, leads to exhaustion, and predisposes to shock and infection The pain of returning sensibility is best controlled by means of an anodyne, its administration being so timed that its effects will coincide with the return of consciousness The most efficacious agent for this purpose is morphin It not only relieves pain but, owing to its stimulating influence on the musculature of the small bowel, it tends to prevent flatulence and by depressing the large bowel spares the patient the peristaltic discomfort inseparable from an attempt to expel the gas Morphin is best given in several small doses since the total quantity administered in a single large dose permits of the accumulation of mucus in the trachea by its depressing effect on the respiratory center and its tendency to abolish the cough reflex The usual dose is 0 01 gram ($\frac{1}{6}$ grain) dissolved in 2 cc of a 50 per cent solution of magnesium sulphate, administered hypodermically in 4 doses at 3-hour intervals In the meantime the respirations are watched, and should they fall below 16, the drug is discontinued If after the first injection the patient displays an idiosyncrasy, any one of the following agents may be substituted. Pantopon 0 02 gram ($\frac{1}{3}$ grain), codein sulphate 0 065 gram (1 grain), sodium amytal 0 4 gram (6 grains), pentobarbital 0 2 gram (3 grains), luminal 0 065 gram (1 grain), pyramidon 0 3 to 0 6 gram (5 to 10 grains), or aspirin 0 3 gram (5 grains)

Headache is a common postoperative sequela and can frequently be relieved by the application of an ice bag Harrison (51) believes it can be prevented by an intra-

venous injection of 120 cc. of a 5 per cent solution of dextrose in physiologic saline solution *immediately after the operation*. *Backache is usually due to stretching* of the ligaments—especially those of the sacro-iliac joint—consequent upon a prolonged dorsal position on the operating table. A pillow placed under the loin or the knees, the application of heat, or an alcohol rub will often be found beneficial.

Local pain in the wound can frequently be relieved by a change of dressing or by the application of dry heat or cold. If procain has been used as an anesthetic, there may be considerable burning for an hour or two after its effects have worn off. Pain which persists for more than 24 hours or develops after an initial subsidence points to some complication. Under such circumstances anodynes should be withheld until the cause of the pain has been investigated and proper therapy for its relief instituted, otherwise, these drugs may mask the symptoms and lead to neglect of the underlying condition.

Water Balance

All patients are actually or potentially dehydrated postoperatively owing to the depletion of fluids through (1) excessive perspiration occasioned by blankets and the overheating of the operating room, (2) increased pulmonary ventilation consequent upon general anesthesia and vasodilatation (3) evaporation of moisture from exposed raw surfaces during the operation (4) restricted intake of fluids after the operation, (5) increased metabolic rate associated with the rise in temperature, and (6) abnormal fluid losses from hemorrhage, vomiting, and diarrhea. In order to prevent the disastrous consequences of dehydration, water balance must be maintained from the outset of the postoperative period. The patient must be provided with 3000 cc. of fluid during the first 24 hours, and if there are signs of dehydration, such as scanty urine and dry tongue, the amount is increased. For the detailed management the reader is referred to Chapter V. As soon as the patient can tolerate liquids warm water is given in small quantities followed by fruit juices sweetened with glucose. If water cannot be taken by mouth, it must be given parenterally (p. 347). Immediately following prolonged operations or those entailing an extensive fluid loss, it is advisable to administer intravenously 1000 cc. of a 5 per cent solution of glucose and saline and to continue the parenteral administration of normal salt solution by means of a slow intravenous drip. Hypodermoclysis and proctoclysis are too uncertain to be of value.

During the first postoperative week a record should be kept of the fluid intake and the output of urine and vomitus, together with an approximate estimate of the quantity of perspiration.

Diet

The details of the postoperative diet will obviously vary in accordance with the age and condition of the patient, the type and duration of anesthesia, and the nature of the operation. After a minor operation performed under a local anesthetic the appetite may be immediately satisfied, provided there is no special contraindication. Following general anesthesia the alimentary canal and digestive secretions are depressed, and for *the first 24 hours* the patient has no appetite, and food is neither

necessary nor desirable Suckling infants, however, should be nursed by the mother immediately upon the return of consciousness, or fed with milk withdrawn by a breast pump and sent to the hospital Water should be administered as soon as the post-anesthetic nausea and vomiting have subsided, at which time it should be given in gradually increasing quantities In the case of undernourished patients albumin or glucose may be added If the oral administration of water aggravates the tendency to vomiting, it should be discontinued and the fluids administered parenterally

On the *second postoperative day* the appetite usually returns, and fluid nourishment consisting of eggnogs, milk, malted milk, orange juice, lemonade, gruels, ice cream, and gelatin, with a liberal supply of glucose, is given at regular intervals in gradually increasing quantities Mason (76) suggests the following sample dietary employed at the Massachusetts General Hospital in Boston

"Liquids with milk

Breakfast	*Dinner*	*Supper*
Orange Juice	Broth	Cream soup
Gruel, milk or cream	Ice cream	Jello
Coffee	Milk	Tea
	Tea	

9 30 A M	*2 30 P M*
Fruit Juice	Orange Juice

Foods Allowed

All foods on 'Liquids without milk' plus

Cream soups	Junket	Cream
Milk	Cocoa	Ice cream

Eggs are *not* allowed"

On the *third day*, or as soon as the patient can tolerate a soft diet, he is given eggs, custards, meat juice, green vegetables, and fruits For breakfast he may receive fruit juice, cereals with milk or cream, soft boiled eggs, buttered toast, coffee, tea, or milk, for lunch, fruit juice, minced chicken or fish, mashed potatoes, bread and butter, milk, tea, or coffee, for dinner, thick soup, jello, spaghetti, cocoa, or milk On the *fourth day* the proportion of solid food is increased, and by the *fifth day* the patient is placed on the routine hospital diet.

Elimination

After an operation the bowels are naturally sluggish, owing to the effects of the anesthetic, the change in diet, and the unnatural position of the patient in bed If they do not move spontaneously on the third or fourth day, measures should be instituted to stimulate their function Drastic purgatives are contraindicated, since these agents lead to gastro-enteritis and dehydration, and increase the activity of the bacterial flora in the intestines The least irritation will be occasioned by the use of a glycerin suppository or an enema composed of 500 cc of normal salt solution or soap-suds, the fluid being administered at a temperature of 100°F. through a well-lubricated tube inserted 10 to 12 cm. beyond the sphincter Equally efficacious is the introduction of 4 to 6 ounces of mineral oil, which is allowed to remain for 2 hours

If there is coexistent flatulence, 30 cc. each of olive oil and turpentine are added to the solution Should these injections fail to secure the desired action, they are repeated in 3 hours If, for any reason, an enema is contraindicated, one of the mineral oils may be given by mouth in 30-cc. doses once or twice on the day before the evacuation is planned, or milk of magnesia may be administered in 6 doses of a teaspoonful each at half hour intervals. If the bowels tend to remain irregular while the patient is confined to bed, mineral oil in 15-cc. doses is administered every evening

The Dressing

The postoperative management of the dressing will depend upon the presence or absence of infection in the wound In any case, dressings should not be changed more often than is necessary, since every manipulation of a healing wound inflicts more or less damage, delays repair, and encourages bacterial growth

As the great majority of aseptic wounds heal by primary intention, there is ordinarily no need to disturb the dressing until the time arrives for the removal of the sutures. But if the patient complains of discomfort or pain, or if there is a discharge or a rise in temperature, the wound should be immediately investigated. The outer dressings are carefully removed and the inner layer raised to permit of inspection of the wound. If the suture line and the surrounding area are dry and free from redness and swelling, the dressing is replaced, and only slight damage will have been inflicted If however, some minor fault is discovered, it is at once corrected tight sutures are loosened, hematomata evacuated, stitch abscesses opened, suture ends which have caught in the dressing released, or drainage in a blocked drainage tube re-established. If the dressings are too tight, they are readjusted, and if they have become caked or saturated, they are replaced by fresh ones. Prompt attention to these details will frequently forestall serious complications.

In the case of infected wounds dressings are changed as frequently as is necessary to keep the surrounding parts from becoming macerated. This may require one or more changes daily As the infection subsides, the dressings may be left on for longer periods. At each change the area around the draining wound is covered with some bland ointment. Moist antiseptic dressings should be changed often enough to avoid concentration of the antiseptic through evaporation of its water content. Fomentations are changed every 4 hours.

Technic of Removal In changing the dressing the same aseptic precautions must be taken as in the operation itself For the sake of convenience, the dressing cart is wheeled to the bedside This cart should contain the following sterile hemostats, tissue forceps, lifting forceps bandage scissors suture scissors, sterile towels xeroform gauze, roller bandages of various sizes, spools of adhesive tape, sponges, large and small dressings, sterile gloves 3 per cent iodin 50 per cent alcohol, hydrogen peroxid, salt solution benzene silver nitrate balsam of Peru sterile vaselin and zinc oxid ointment wooden applicators, tongue blades safety pins, and a paper bag for the disposal of soiled dressings. After removing the outer layers of the dressing with a forceps, the surgeon dons sterile gloves and drapes the field with sterile towels. The part of the dressing immediately over the wound is then carefully peeled off in the direction of the suture line with sterile forceps (fig 207) Adherent dressings are treated with great gentleness. If much pain is inflicted in the process, the wound

is being unnecessarily traumatized Softening the dressings with salt solution or sterile albolene an hour or two beforehand will materially assist in their removal. The wound secretions are mopped away by means of a sponge held in a dressing forceps, after which the area is gently cleansed with gauze dipped in some bland solution, and a fresh dressing applied

If a drainage tube has been resorted to, the proper time for its removal will depend upon the condition which demanded its use. If its purpose was to permit of the escape of blood and serum it may be dispensed with in 24 to 36 hours, but if it was introduced for the removal of pus, each case must be decided on its merits If the infection is superficial and the discharge slight and inoffensive, drainage may be discontinued at the end of 48 hours since after this time the lymphatics are sealed and further extension of the process is unlikely In the case of deep infections, however, the drain is allowed to remain for as long a time as is necessary for the wound to fill up from the bottom with granulations

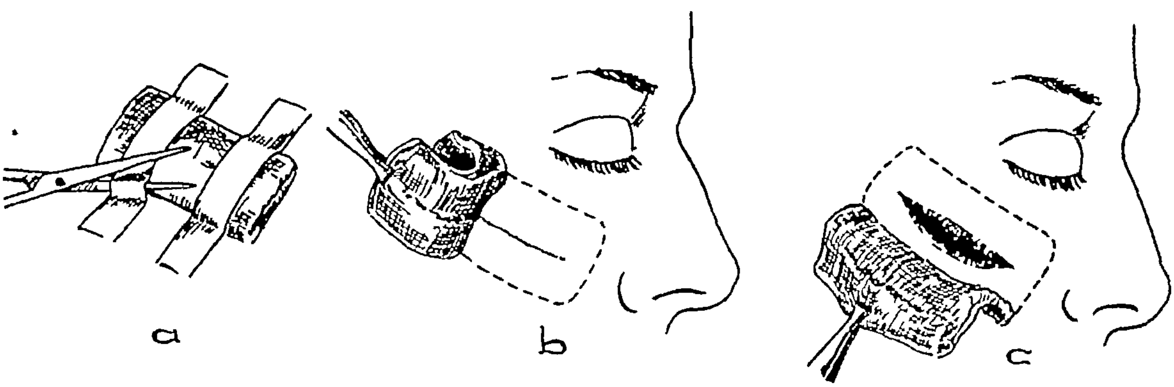

FIG 207 Removal of dressing *a*, adhesive plaster cut, ends left attached for application of new strips *b*, dressing peeled off in direction of wound, to minimize disturbance of suture line *c*, dressing removed across axis of wound, causing disturbance of suture line and separation of wound margins (Christopher's Surgery)

Removal of Sutures

Sutures should be removed as soon as organic union has taken place The longer they remain in the tissues after having served their purpose, the more likelihood there will be of a conspicuous scar A definite time for their removal cannot be arbitrarily stated, as this will vary in accordance with the nature of the wound, the degree of tension under which the margins were approximated, and the suture material employed On exposed areas, such as the face, they may safely be dispensed with on the third or fourth day, provided the wound has been properly closed and the edges lie in easy apposition Some surgeons advise that they be taken out as early as 24 hours following their introduction, but apparently nothing is gained by so doing, aside from predisposing to wound separation, it will not assure an improvement in the appearance of the resultant scar. If the wound is not entirely healed by the third or fourth day, alternate stitches may be removed at that time and the balance on subsequent days, the number depending on the rate of healing. In the case of wounds on covered parts of the body, sutures may be left in place for a week or longer, according to the healing power of the patient Tension sutures are left in for 8 to 10 days, but in no event should they be allowed to remain for a longer period since after this they serve no useful purpose and are likely to cut through the tissues

Sutures are removed as follows The operative field is draped with sterile towels and the hands sterilized and encased in gloves. Because moist sutures are more easily manipulated than dry, it is advisable to soak the suture line previously with some oily substance, such as albolene. The use of hydrogen peroxid is contraindicated, as the bombardment of the liberated gas may separate the wound margins. Irrespective of the type of suture, its removal should be accomplished in such a manner that no part of it lying on the skin be forced beneath the surface In the case of an interrupted suture the knot is grasped with a fine plain dissecting forceps and lifted at right angles to the skin surface no great traction being exerted, lest the opposite limb of the suture be forced into the tissues. With the blades of a pair of fine straight scissors straddling the suture the tissues on either side are gently depressed, and the subcutaneous part of the suture is cut With the scissors supporting the tissues, the suture is removed (fig 208) To remove a subcuticular suture one end is grasped

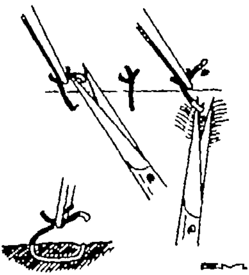

FIG 208. Removal of sutures Knot grasped with plain forceps and lifted at right angles to skin surface With blades of scissors straddling suture, tissues depressed and subcutaneous part of suture cut, as shown in insert. With scissors supporting tissue on other side, suture withdrawn. Thus no part of suture lying on skin is forced beneath surface

with a forceps, and while the wound is steadied, gentle traction is exerted and the suture is withdrawn If it breaks, the lost part must be recovered, either it must be fished out with a fine hook, or, if necessary, a part of the wound must be reopened.

Following the removal of the sutures the parts are reinforced for several days to guard against disruption of the wound by the pull of the underlying muscles. This support can be supplied by strapping the sides of the wound with elastoplast placed over a gauze dressing, or by the application of strips of collodion or zinc oxid plaster disposed in such a manner that they will cross the wound at right angles In the latter case the portion lying immediately over the scar should be folded so that the adhesive surface will not come in contact with the wound.

VOMITING

Postoperative nausea accompanied by vomiting is a common sequela, especially following general anesthesia. Its incidence and severity will depend upon the individuality of the patient, those with nervous temperaments and a predisposition to sea

sickness being most susceptible. Fortunately, however, it is not as common as formerly, owing to the more rational preoperative preparation, more skilful anesthesia, and gentler surgery. Nausea and vomiting following operation may be the result of (1) reflex stimuli arising from (a) retained secretions consequent upon arrested peristalsis, swallowed blood, or the irritative effect of the anesthetic agent on the gastric mucosa, or (2) direct stimulation of the vomiting center in the medulla by toxic agents in the circulation, such as the anesthetic and broken-down tissue products. (3) Psychologic factors.

The initial postoperative vomiting which accompanies the re-establishment of the reflexes may be beneficial in that it rids the stomach of swallowed foreign material, but if allowed to continue, it not only contributes to dehydration, hypochloremia, gastric dilatation, and exhaustion, but also increases pain and jeopardizes the suture line.

The tendency to vomiting can be materially reduced by recourse to measures for the prevention of dehydration and exhaustion of the glycogen reserve—namely, the administration of sufficient quantities of fluid and the prescription of a diet rich in carbohydrates. Kemp finds the preoperative administration of Lugol's solution 0.65 gram (10 minims) and desiccated suprarenal cortex 0.4 gram (6 grains) beneficial. The incidence of vomiting may also be reduced by the use of basal narcotics, nitrous oxid and oxygen, and local anesthetics. If ether is employed, the quantity should be reduced to a minimum and the patient's head kept low and to one side, so as to prevent the introduction into the stomach of mucus saturated with the anesthetic. Other preventive measures consist of gentle manipulation of the tissues during operation and avoidance of jolting during transportation.

In cases of prolonged surgery or unsatisfactory reaction to anesthesia postoperative vomiting is to be expected and may be mitigated if, before the patient is taken out of the operating room, the ether-laden mucus is washed out of the stomach with a bicarbonate solution. Or, as soon as he regains consciousness, the stomach may be emptied by the administration of a glass of warm water to which one teaspoonful of sodium bicarbonate has been added. Should the nausea and vomiting persist after the initial emptying of the stomach, it can frequently be relieved by pellets of ice held in the mouth, an ice compress around the neck, heat applied to the epigastrium, sips of tea or coffee, teaspoonful doses of whiskey, lemonade sweetened with a little glycerin, or charged mineral waters. Ten minims of 1:1000 adrenalin solution in cold water or 30 grains of potassium bromid and 25 grains of chloral hydrate administered in the form of an enema are often beneficial. Hewitt (55) recommends an enema containing potassium bromid 20 grains and aspirin 15 grains dissolved in salt solution. If the emesis is of a nervous character, reassurance and sympathy may be all that is necessary.

Should the above measures fail, the use of a Levine tube or a Wangensteen suction apparatus is resorted to to keep the stomach empty (fig. 209). While vomiting continues, the intake of food should be restricted. However, if the emesis is one of nervous origin, the ingestion of small quantities of solid food is frequently beneficial.

If the vomiting persists or does not appear until 24 hours following operation, acute dilatation of the stomach should be suspected. This condition is characterized by epigastric distress, rapid distention, and projectile vomiting of large quantities of fluid out of all proportion to the volume ingested. Examination discloses a large area of

gastric dulness. The symptoms if not relieved, are soon followed by evidences of dehydration The exact cause of this disorder is unknown but it is thought to be due to a paralysis of the gastric musculature In such cases the stomach should be washed out repeatedly until the ejected fluid returns clear Small doses of pituitarin are administered and the oral intake of fluids prohibited, water balance being maintained parenterally

Flatulence and Gas Pains

Some degree of abdominal distention is present after all operations as a result of emotion, the toxic effect of the anesthetic agent, excessive purging, the trauma of operation, etc While the exact mechanism of the condition is unknown it is probably due to a sympathetic imbalance Normal peristalsis is dependent upon an inter action of the impulses sent by way of the three segments of the autonomic nervous system, the upper cranial and lower sacral divisions stimulating intestinal activity and the central segment tending to retard it. It is believed that the adverse factors associated with operation depress the cranial and sacral divisions, causing an inhibition of peristalsis. As a result, the atmospheric air swallowed during the course of anesthesia accumulates and cannot be absorbed since it is composed of 79 per cent of non-absorbable nitrogen. This accumulation together with the retained putrefactive gases give rise to distention and cramplike pain.

Obviously, if treatment is to be effective, it must be directed toward the removal of the underlying cause, and since there is a great difference of opinion as to the factors responsible, many diversified practices exist. All clinicians agree, however, that the incidence of postoperative distention can be diminished to a great extent by the maintenance of water balance and of the pH and mineral content of the blood proper psychic management, avoidance of purgation by the use of drastic cathartics or vigorous enemas, judicious use of preoperative sedatives, and adherence to an atraumatic and aseptic surgical technic. Some surgeons advocate stimulation of peristalsis by the administration of fluids and semisolid foods as soon as nausea and vomiting have subsided. Others (83 85), however, prohibit all oral ingestion on the grounds that gastro-intestinal rest will more quickly restore the normal intestinal tone

As soon as distention appears, efforts should be made to combat it, because, aside from the discomfort and pain which it occasions, it provokes venous stasis, and by its crowding effect interferes with the function of the heart. If the distention is gastric, the patient can often be relieved if he is propped up in bed and given a drop of peppermint oil or 4 or 5 drops of oil of turpentine on a piece of sugar or bread, if it is intestinal, a change in position, a loosening of constricting bandages, or the application of a turpentine stupe may be all that is necessary Should these measures fail, a rectal tube may be inserted and left in place for several hours. Enemas of various compositions, including soapsuds glycerin and water, olive oil, and milk and molasses, have been advocated but since they flush only the lower bowel and fail to stimulate peristalsis, the rectal tube is preferable, as it serves the same purpose and does not have the irritating effect of the solutions. In this respect Ochsner (82) observes "It is irrational to assume that the gastrointestinal tract which is functionally inactive and already unable to empty itself of its contained fluid and gas will function normally

after further overloading it by the administration of additional fluid in the form of an enema" Fine, Hermanson, and Frehling (37) endeavor to remove the intestinal nitrogen by lowering the tension of the nitrogen in the blood stream. This they accomplish by replacing the ordinary air-intake with 95 per cent oxygen. In order to prevent toxicity, they interrupt the administration of the gas every 4 to 8 hours for a period of ½ hour or longer

In more obstinate cases the intestines can be relieved of accumulated gas and fluid by continuous suction siphonage by means of a duodenal tube which is left in place until the normal peristaltic function is resumed (86) Adams and Bancroft (1) resort to the device illustrated in Figure 209 "At the onset the upper bottle is filled with water except for 400 cc and the lower bottle is empty except for 400 cc in the bottom to cover the tube The amount of gas taken off is read directly on the upper bottle, and the amount of fluid removed is shown on the lower bottle Multiple perforations

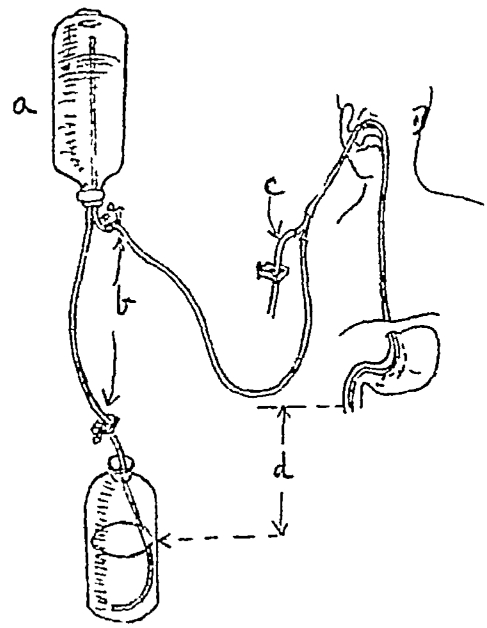

FIG 209 Continuous suction siphonage by means of duodenal tube For details, see text (Paine, Carlson, and Wangensteen)

are essential on the distal end of the nasal tube to permit gastric and duodenal siphonage It is also important to make sure that the tube from the patient is connected with a long piece of glass tubing in the upper bottle Small amounts of clear fluids are allowed as desired by mouth at all times as they are immediately withdrawn by the tube . The tube is passed in 2 or 3 inches every two hours for the first 12 hours in order to facilitate its passage into the duodenum"

Various drugs have been suggested for the stimulation of peristalsis, among them being pituitary extract, prostigmin, eserin, and acetylcholin Pituitary extract is administered at 4-hour intervals in doses of 0 01 gram ($\frac{1}{6}$ grain) Levis and Axelman (69) advise the use of prostigmin in 1-cc doses of a 1 2000 solution Eserin is given in doses of 0 0003 gram ($\frac{1}{200}$ grain)

HICCOUGH (SINGULTUS)

Hiccough is a common postoperative manifestation characterized by clonic contraction of the diaphragm with simultaneous closure of the glottis As a rule the

condition is transient and disappears spontaneously, but occasionally it persists despite all attempts to relieve it and causes anxiety by its interference with rest and nutrition. Although the mechanism of its production is obscure, it is usually attributed to some disturbance of the reflex arc, the vagus or splanchnic nerve comprising the afferent and the phrenic the efferent segment. The initiating factor is either neurotic, mechanical caused by the presence of irritating substances in the gastro-intestinal tract, or infectious presumably due to some bacterium not yet defined. Hiccough of the latter type is inclined to be protracted and may last for several days.

A wide variety of measures, both physical and chemical, have been advocated for the relief of hiccough Most of these are empirical and their efficacy cannot be depended upon in all cases. Of the physical remedies, the following have been found to be the most helpful Inhalations of 10 to 30 per cent carbon dioxid-oxygen. Golden (42) suggests that in the absence of a gas machine the patient be made to breathe into a paper bag for 3 to 5 minutes thus receiving with each inhalation air which is constantly increasing in carbon dioxid content. Other mechanical measures suggested are the drinking of water while the breath is held, traction on the tongue, compression of the chest by flexion of the thighs on the abdomen, digital pressure directly over the phrenic nerve or on the eyeball, and ethyl chlorid spray or an ice bag applied to the upper abdomen Antispasmodics such as nitroglycerin 0 00065 gram ($\frac{1}{100}$ grain), amyl nitrite or atropin 0 00065 gram ($\frac{1}{100}$ gram) and sedatives such as chloral hydrate, bromids, Hoffman s anodyne, barbiturates and morphin, are frequently employed to advantage. Finally, gastric lavage or constant suction through a nasal-duodenal tube will often bring relief when all other attempts have failed. In rare instances the condition is so severe as to necessitate such heroic measures as the stretching or cutting of the phrenic nerve.

Postoperative Retention and Suppression of Urine

Retention

Retention of urine is a frequent and troublesome postoperative sequela, its incidence depending mainly on the length of the operation and the type of anesthetic employed It seldom follows local anesthesia but is common after the use of spinal and general anesthesia. Jordan (63) reports a 19.3 per cent incidence following spinal 12.5 per cent following ether, and 27 per cent following nitrous oxid-ether anesthesia. The cause is probably of a reflex nature Under ordinary conditions nerve impulses traveling over the path of the sympathetics parasympathetics, and pubic nerves are able to maintain the physiologic relation between the detrusor and sphincter muscles of the bladder As a result of the inhibiting effect of the anesthetic on the reflex arc, the impulse that initiates micturition is nullified. Thus the bladder is allowed to fill up beyond the limits possible in the normal state of sensibility In time as the reflex arc becomes exhausted, the sphincter in turn relaxes and incontinence follows.

The symptoms of retention are characteristic. The patient complains of pain and discomfort, and if the bladder is not emptied, dribbling of urine takes place due to overflow—the so-called paradoxical incontinence. Examination of the hypogastric region discloses a visible swelling, perceptible to the touch as a tense, tender, movable mass with a rounded upper margin merging below with the symphysis. Palpation

through the rectum reveals the distended organ, and percussion yields evidence of an area of flatness. If a catheter is passed, a large quantity of urine will be evacuated

Management The average patient can safely go 12 to 14 hours after operation without urinating, since in the early postoperative period little urine is secreted, owing to dehydration and suppression of the renal function by the anesthetic. After this period, however, he should be encouraged to empty his bladder, in order to prevent paralytic distention Should no urine be passed after 14 hours, the abdomen should be examined If the bladder has not risen above the pubes, no anxiety need be felt If, however, the organ is distended, attempts should be made to promote normal urination Some patients, especially those who are apprehensive and hypersensitive, are unable to permit the bladder to function under stress or in a horizontal plane In such cases all that may be necessary for the proper stimulation will be to place them in a sitting position in bed and then leave them to themselves Frequently the impulse can be initiated by the application of heat over the pubes, by means of a warm urinal or bed pan, a warm enema, a turpentine stupe, or the sound of running water Chemical agents may likewise be employed, such as strychnin, pituitarin, or physostigmin Jordan (63) advocates the oral administration of ½ ounce of potassium acetate in a dilution of 1:15 every half hour

If conservative measures fail, catheterization must be resorted to and should not be delayed, since infection is more likely to follow this procedure when the bladder is overdistended (5) It should be performed under the strictest asepsis Wheeler (104) employs the following technic. "The anterior urethra harbours many organisms. It is never quite certain that a catheter can be passed without some slight trauma to the lining epithelium The smallest microscopical break in this lining may allow the escape of organisms or their products into the tissues beyond On the other hand, microbic infection may be carried by the catheter into a bladder already suffering from the effects of prostatic or other obstruction Infection of the stagnant urine and cystitis may be the result " The anterior urethra may be washed out with an ordinary urethral syringe The surrounding area is prepared in the following manner "The prepuce is retracted and the glans thoroughly washed with some suitable solution The skin of the scrotum, penis, lower portion of the abdomen and inner side of the thighs is similarly treated before the application of sterile sheets or towels The penis is wrapped in sterile gauze " If a metal catheter is to be used, "the buttocks are brought to the end of the table and the legs are spread apart and supported by low crutches or suitable slings. . The surgeon stands between the legs . If the patient lies prone—as some prefer—the surgeon stands on the left side of the table The penis, surrounded with sterile gauze, is held upwards with the left hand, in a midline position, pointing obliquely towards the ceiling " The metal instrument "is taken from the sterilizer, and while still warm is smeared with freshly sterilized liquid paraffin, glycerin, or olive oil Lubricants obtained from previously opened collapsible metal tubes are not so safe The nose of the instrument is introduced into the meatus while the shaft lies in a position approximately parallel to Poupart's ligament The left hand pulls the penis well forward on to the catheter. The shaft of the latter is rotated until it lies in the line of the linea alba, between the umbilicus and pubes The instrument is now gradually raised until the point has travelled to the region of the bulb At this stage, if difficulty is experienced, the progress of the catheter

may be accelerated by pressure on the perineum or a finger in the rectum. The handle of the catheter is now vertical, the nose is entering the membranous portion of the urethra. Finally the handle is gently lowered between the thighs, the tip is in the bladder, urine flows, and free rotation of the instrument becomes possible. A metal instrument as a rule overcomes any spasm of the compressor urethrae muscle if slight pressure is exerted and a few seconds allowed to elapse If a local anesthetic has been employed, delay by spasm is seldom experienced If spasm is prolonged and persistent, the catheter may be connected with a funnel or douche and hot lotion allowed to run in under moderate pressure the spasm gives way, and the catheter slips readily into the bladder '

If a gum elastic or rubber catheter is to be used, Wheeler (104) states that "the coudee variety is best for general purposes. If provided with a stylet it can be curved and made semi rigid resembling the metal instrument. The catheter is taken from the sterilizer, allowed to cool, and is lubricated in the same manner as the metal variety It should be lifted by its proximal end no part which is to enter the urethra should be touched The penis, surrounded by gauze, is held upwards with the left hand, the nose of the catheter is introduced into the meatus and the instrument is easily insinuated onwards into the bladder After catheterization, as a prophylaxis against cystitis argyrol should be instilled into the bladder and urethra as the catheter is being withdrawn.

Suppression

Suppression of urine must be differentiated from urinary retention inasmuch as the treatment of the two conditions is entirely different Suppression may be due to kidney failure (secretory anuria) consequent upon dehydration or to spasm of the ureters (postrenal anuria) Its incidence can be reduced by means of a liberal fluid intake before and after operation (p 343) If the urinary output falls below 800 cc., the kidney should be stimulated by the introduction of water, orally or parenterally Glucose, especially in hypertonic solutions, is an excellent diuretic and is administered in amounts of 1000 cc. of a 10 per cent solution 2 or 3 times in 24 hours (p 350) Means should also be instituted to stimulate elimination through the skin and bowels by the use of hot packs, diaphoretics and purges

Postoperative Hemorrhage

Hemorrhage is one of the most alarming postoperative complications and unless promptly recognized and properly dealt with, it may claim the life of the patient. Fortunately its incidence has been greatly reduced since the development of atraumatic and aseptic technic, the improved quality of suture materials, and the adoption of prophylactic preoperative measures in patients with a hemorrhagic tendency

There are three types of postoperative hemorrhage classified, according to time of appearance, into (1) primary, (2) intermediate and (3) secondary Primary hemorrhage occurs immediately following operation and is due either to inadequate hemostasis or to some interference with the coagulability of the blood, such as anemia, hemophilia, purpura, or leukemia. Intermediate hemorrhage occurs within 24 hours after operation The usual etiologic factors are slipping of an improperly tied

ligature, mass ligation, or the expulsion of a blood-clot lying in an unsecured blood vessel In the latter case the expulsion may be brought about by (1) the increased strength of the heart action following recovery from shock, (2) undue restlessness, coughing, or excitement, or (3) the injudicious administration of stimulants Secondary hemorrhage begins any time after 24 hours, and the later it supervenes the more serious the prognosis Its appearance 2 or 3 days after operation usually implies the involvement of a small vessel, while its occurrence on the eighth to the tenth day would point to a larger trunk It is usually due to infection, the suppurative process causing a softening of the vessel walls with an eventual breaking down of their resistance to the blood pressure Less commonly it follows upon erosion of the vessel wall from pressure of a drainage tube or a spicule of bone. Occasionally it is brought about by a ligature which has been tied so tightly that it cuts through the tunica intima and media of the blood vessel, the outer coat giving way when no longer able to resist the force of the circulation Contributary causes include impaired nutrition of the vessel wall through undue stripping up of its sheath, arteriosclerosis, and general conditions responsible for hypertension

Management Postoperative hemorrhage is usually *preventable* *In the preoperative period* patients should be examined for a hemorrhagic tendency, and adequate prophylactic measures adopted Patients with a hemorrhagic diathesis should be blood-grouped and a donor kept in readiness, so that a transfusion may be carried out promptly if the need arises Operation should be avoided when possible in tissues that show evidence of passive congestion During the operation precaution should be taken to secure complete hemostasis by a careful tying of ligatures. When hemorrhage is anticipated, the dressings should be frequently inspected

At the first evidence of bleeding all efforts must be directed toward its immediate control Even slight hemorrhage should receive due attention, as it may be a precursor to a more serious one Temporary hemostasis can usually be effected by digital compression either over the bleeding point or over the main trunk against a resistant structure (p 266) While the vessel is being compressed, the wound is reopened, all coagula are removed, and a search is made for the bleeding point. If the bleeding is from vessels too small or too numerous to be ligated, hemostasis can be effected by the application of heat or cold, by packing the wound with sterile gauze, or by applying an actual cautery to the area

If the bleeding originates in a large artery, both ends of the vessel should be caught with hemostats and ligated, lest hemorrhage occur from the distal end after the anastomotic circulation has been established While the proximal extremity of the vessel is readily located, identification of the distal end is often difficult, due to its tendency to retract within the tissues It may even become necessary to administer an anesthetic and enlarge the wound for the purpose If the bleeding vessel cannot be located, or is so situated that exposure and ligation would incur danger to important surrounding structures—as, for instance, in the pterygoid region—or if the tissues in the vicinity are infected or so friable that they will not hold a suture, ligation of the vessel in continuity must be resorted to, despite the objectionable features of this method—i e, the necessity of inflicting an additional wound and the uncertainty of the hemostasis, especially in locations where collateral circulation is abundant

The treatment of venous hemorrhage does not differ from that of arterial In the

ligation of a large vein of the neck, however, the wound should be kept flooded with saline solution, since the negative pressure in this location predisposes to air embolism.

The general treatment of hemorrhage includes measures (1) to combat shock, (2) to supply blood volume, (3) to favor coagulation of blood in the vessels, and (4) to stimulate the blood forming organs. (1) The methods employed to combat shock are discussed on page 386 (2) The blood volume lost in hemorrhage is best replenished by recourse to a blood transfusion, which not only furnishes liquid to raise the blood pressure but also supplies oxygen-carrying cells. In the absence of a donor, the volume may be restored by the intravenous administration of normal salt solution or 5 per cent dextrose. Whatever the nature of the fluid introduced, an attempt should be made to secure a pressure sufficiently high to supply the medullary centers and yet not so high as to increase the hemorrhage or cause its recurrence by the forcing of a blood-clot out of an unsecured vessel. (3) To promote clotting in the vessels and thus effect an arrest of hemorrhage, many coagulants have been advocated among which are thrombokinase, foreign proteids, such as blood sera of animals, thrombin preparations obtained from snake venom, and chemical agents like ergot and adrenalin. Calcium chlorid and calcium lactate have also been suggested on the grounds that calcium is necessary for blood coagulation, but the value of these preparations has probably been overemphasized However, since they do no harm, they may be given in 30-grain doses every 4 hours. Morphin is a valuable agent, for while it has no effect on the coagulability of the blood, its sedative properties allay the restlessness associated with hemorrhage and thus favor clotting (4) Finally, to stimulate the blood-forming organs, a nutritious diet, rest, and chemical agents, such as iron and arsenic, are prescribed.

Postoperative Infection

Infection represents one of the most serious postoperative complications, and it is therefore of the utmost importance that it be recognized and treated before it has had an opportunity to invade the surrounding tissues. The majority of infections are preventable and can be traced to some break in the surgical technic. The precautionary measures are discussed in detail in Chapter I A rise in temperature to 99 or 100°F within the first 24 hours following operation is to be expected and is of little significance It usually returns to normal by the second or third postoperative day While the reason for the rise is not known, it is assumed to be due to the absorption of aseptic products consequent upon the trauma of operation. An elevation in temperature appearing on the third to the seventh day, however, is to be regarded with suspicion, especially in the presence of a quickened pulse and local pain, and under such circumstances immediate investigation is imperative to determine the underlying cause. While meddlesome postoperative treatment is reprehensible the proper time to deal with infection is when its symptoms appear and not after it has advanced to the stage where it endangers repair Under aseptic precautions the dressings are removed and the wound examined for evidences of hematomata, collections of fluid, and pus. A hematoma is perceptible to the touch as an indurated or fluctuant mass, and if found should be evacuated Between 2 sutures a delicate pair of forceps is introduced. The blades are separated in the wound, the instrument withdrawn, the hematoma evacuated

and a pressure bandage applied to obliterate the remaining dead space Unless such precaution are taken, a brownish discharge may ooze from the wound for several days If infection is suspected the wound is opened by means of a blunt probe, and if pus exudes, 2 or 3 sutures are removed, the wound spread, the pus evacuated, and a small rubber drain inserted Fomentations are then applied and the wound treated as outlined on page 279 A specimen of the pus should be sent to the laboratory for bacteriologic examination

If these procedures do not effect a fall of temperature and the local appearance of the wound suggests infection of the deeper tissues, all sutures must be removed and more extensive drainage instituted (p 65)

Thrombosis and Embolism

Postoperative thrombosis is a matter of grave concern, as it leads to disabling thrombophlebitis with its protracted convalescence and entails the ever-present danger of the loosening of the clot and its lodgment in the form of an embolus in the pulmonary veins or some other vessel supplying a vital organ—an eventuality which may result in death Postoperative thrombosis is most likely to occur after abdominal and pelvic operations, and in obese patients or those suffering from cardiovascular diseases It is most common in persons between the fifth and sixth decades of life Its etiology is unknown, but the following factors undoubtedly predispose to its production: (1) Conditions which tend to change the nature of the vascular endothelium, such as trauma, ligation of small veins at points where they join parent trunks, inflammation, and infection (2) Alterations in the character of the blood by the toxic action of the anesthetic, by dehydration, anemia, and hemorrhage A milk diet has been held responsible for thrombosis, on the grounds that it increases the amount of calcium salts in the plasma (3) Factors which retard the circulation, notably tight bandages, postoperative distention, restriction of muscular movements of the legs, and a prolonged recumbent position

The character of the thrombus will vary in accordance with the rate of its formation If it develops slowly, it is the so-called white thrombus, composed principally of fibrin, if rapidly, it is a red thrombus, with erythrocytes incorporated in the fibrin A part or the whole of the thrombus may become detached and be carried along in the circulation as an embolus until it reaches a site narrow enough to arrest its course, usually at the point of bifurcation of some large vessel The favorite sites of obstruction are the bifurcation of the common femoral, the common iliacs where they bifurcate into terminal branches, the brachial at the bifurcation of the radial and ulnar, the popliteal, the axillary at the point where the subscapular branches diverge, and the pulmonary After lodgment of the embolus the effect it produces will vary in accordance with the nature of the collateral circulation In the case of an artery without collateral circulation the part may undergo gangrene The consistency of the embolus depends upon the time of its formation If dislodged before it is completely organized, it will be soft and have a tendency to break up into several small emboli or to straddle the bifurcation of the blood vessel, but if it separates after the thrombus has undergone some organization, it is firm, retains its form, and will be likely to plug a single vessel

Thrombosis seldom supervenes before the eighth postoperative day and may not

appear for several weeks The symptoms appear gradually, accompanied by a rise in temperature If the femoral vein is involved, the leg becomes swollen, painful, and tender, especially along the course of the venous trunk, which on palpation feels like a hard cord. The part is cyanotic but the pulse remains perceptible. Should embolism ensue, its onset will be sudden and associated with severe cramplike pain along the course of the obstructed vessel, soon to be followed by tingling sensations and finally by anesthesia and loss of function The part appears blanched is cold to the touch and the pulse is intercepted in the area beyond the embolus

There are no specific preoperative measures that can be adopted for the prevention of thrombosis. Bancroft and his associates (4) believe that a carbohydrate and fluid diet, with a restricted fat and protein intake, and the intravenous administration of sodium thiosulphate will lessen the tendency to the condition. Of late heparin isolated by Howell and Holt (57) in 1918, has enjoyed much favor as an anticoagulant, but it has not had sufficient application to demonstrate its worth

Postoperatively, measures should be adopted to facilitate the return flow of blood to the heart Immediately after operation the patient is placed in a 15 degree Trendelenburg position, and, if there is evidence of a predisposition to thrombosis, this position is maintained until the fourth postoperative day (96) Mobilization and massage of the legs is instituted early The patient is instructed to exercise his legs several times daily by imitating the motions of a bicyclist (fig 206) Tight abdominal dressings should be avoided as they tend to compress the femoral veins. Walters (99) advocates the administration of desiccated thyroid extract as a stimulus to the circulation

Once embolism has developed, antispasmodics are used to overcome the arterial spasm resulting from the lodgment of the embolus. Papaverin hydrochlorid in 0 03-gram (½ grain) doses, or sodium nitrite in 0 06-gram (1 grain) doses given intravenously improve the circulation by their vasodilatory action. In addition, De Takats (29) advises that the part be placed in a heat cradle. "The temperature in the cradle need not exceed 90 degrees F The limb should not be elevated, as it commonly is, because elevation only decreases arterial inflow, on the contrary, it should be in a dependent position, somewhere between 10 and 15 degrees below the horizontal position. The angle must be so selected that the tips of the extremity regain their normal color" The circulation in the affected limb may be further stimulated by the use of a negative and positive pressure apparatus

If the above procedures do not produce a rapid improvement, surgical removal of the blood-clot by an embolectomy or arteriectomy may be undertaken

Embolectomy

This operation was first successfully performed by Lobey in 1911, and the increasingly favorable results have since placed it in the foreground of emergency surgery It finds its greatest application in the treatment of embolism of the lower limbs, the upper limbs seldom requiring the operation because of their free collateral circulation The sooner an embolectomy is performed the better the prognosis The optimal time is within 2 to 3 hours after the appearance of the symptoms. If 9 hours have elapsed, it is of little value since by this time degenerative changes will have taken place in the blocked artery

Under local anesthesia the obstructed artery is exposed through a free incision, and the wound flushed with sodium citrate solution The vessel is clamped at a point above the embolus and incised over the clot The artery is then held open by means of traction sutures passed through its outer coat and the clot is removed There should now follow bleeding from the distal end of the artery The absence of such bleeding would indicate an obstruction lower down, and in such a contingency the clot must either be fished out with a forceps or another incision be made in the vessel over the site of obstruction When bleeding from the distal segment begins, this end is clamped and the clamp on the proximal side of the incision is released for the expulsion of any clots which may have collected The clamp is then reapplied, the wound irrigated with citrate solution, and the vessel closed in the manner outlined on page 295

Arteriectomy

Extirpation of the thrombosed artery followed by an end-to-end anastomosis was first suggested by Gosset (43) in 1933 He believes this operation to be superior to embolectomy in that it is easier to perform, involves no danger of injuring the intima, and relieves the peripheral vasoconstriction

Respiratory Complications

Respiratory complications develop in about 2 per cent of all operative cases, irrespective of the type of anesthetic employed, and are the cause of 0 5 to 0 6 per cent of all postoperative fatalities They range in severity from a transient bronchitis to a massive pulmonary collapse Rovenstine and Taylor (94) cite the following statistics based on 7,874 cases Slight cough, 3 6 per cent, severe cough, 1 1 per cent, partial pulmonary collapse, 0 3 per cent, massive pulmonary collapse, 0 2 per cent, pneumonias in all forms, 0 7 per cent, laryngitis, 1 8 per cent, bronchitis, 0 3 per cent

The incidence of postoperative respiratory sequelae is influenced by the same etiologic factors that govern pulmonary diseases in general Thus, individuals in the extremes of age, the obese, the debilitated, and the intemperate are predisposed Some of the more important factors which increase the susceptibility are respiratory infection, oral sepsis, undue chilling of the body, and prolonged operations Rovenstine and Taylor (94) found that in operations lasting more than one hour the number of pulmonary complications was twice as high as in those requiring less than an hour, and that in operations requiring two hours the incidence was three times as high as in those requiring one hour The location of the operative site also plays a part According to King (64), pulmonary complications are twelve times more common following abdominal operations than following those on other parts of the body

Etiologic Factors

The etiology of postoperative pulmonary complications is not definitely established, but certain factors naturally come to mind: (1) aspiration, (2) interference with respiratory movements, and (3) embolism

(1) **Aspiration.** Respiratory complications have been attributed to the aspiration

of foreign material consequent upon a careless induction of anesthesia. The convulsive respiratory movements of the struggling patient tend to draw into the lungs the bacteria laden mucus, which is retained owing to congestion, edema, spasm of the bronchioles, and absence of the cough reflex induced by the anesthetic. Fortunately, this mode of production has become comparatively rare, due to the greater attention given to the preoperative elimination of oral and respiratory infection, the more careful choice of the anesthetic agent and the improved technic in its administration.

(2) **Interference with Respiratory Movements** Anything which hampers respiratory movements predisposes to pulmonary complications by lowering the vital capacity After abdominal operations the associated paresis of the diaphragm results in an elevation of the dome and the consequent pressure on the base of the lungs leads to collapse The nearer the operative site to the diaphragm, the greater the danger of pulmonary complications Statistics show that their incidence is twice as frequent after upper abdominal operations than after lower Other factors which diminish respiratory movements are pain, tight bandaging, abdominal distention, faulty posture during operation, depressive drugs, and general weakness from preoperative starvation or purgation

(3) **Embolism.** Respiratory complications may result from thrombi formed in some part of the venous system and carried to the lung as emboli (25) Normally, muscular contraction and the negative pressure of respiration combine to return the venous blood to the heart. After operations the characteristically shallow breathing and the immobilization of the chest interfere with this return and thus predispose to thrombosis and embolism Duval and Binet (31) are of the opinion that embolic factors are responsible for the majority of postoperative pulmonary complications. They believe that the breaking down of the proteins of the tissue into polypeptids as a result of the operative trauma results in the liberation of thrombus-producing substances into the circulation

Classification

While a classification of the various postoperative pulmonary complications would be most desirable, it is impossible to integrate the clinical patterns with the pathologic findings. For the sake of convenience however these complications will be grouped as follows (1) infectious—as for example bronchitis pneumonia and pulmonary suppuration, (2) obstructive—such as pulmonary collapse and (3) vascular as for instance, pulmonary embolism and infarction.

(1) **Bronchitis.** Bronchitis is the most common pulmonary complication and manifests itself within 48 hours after the operation. It does not differ in symptoms or physical signs from non-operative bronchitis and usually disappears in a few days without residual lung damage.

(2) **Pneumonia.** Postoperative pneumonia may be lobular or lobar The former is more common and usually develops within a few hours after operation As a rule the time of onset bears some relation to the severity of the condition, the earlier it appears, the more grave the prognosis. If the patient recovers, convalescence is protracted and the lung is apt to be permanently damaged. Postoperative lobar pneumonia usually supervenes 7 to 10 days after operation, and its symptoms and

signs are similar to those of non-operative pneumonia It usually runs a mild course leading up to an early crisis

(3) **Pulmonary Suppuration.** Pulmonary suppuration is most prone to occur after operations on the nose, mouth, and pharynx, and is probably due to aspiration of foreign material. In the acute stages the symptoms are similar to those of pneumonia, to be followed later by evidences of lung abscess

(4) **Pulmonary Collapse.** This complication has been the subject of much investigation in the past few years and has come to be considered as an entity rather than as a manifestation of the so-called ether pneumonia It ranges from a partial collapse of a lobe to a massive collapse of the entire lung base The symptoms obviously depend upon the degree of pulmonary involvement In the great majority of cases the condition appears within the first 48 hours after operation, although occasionally it does not supervene until the second week The onset is abrupt, and due to the sudden mediastinal displacement consequent upon the drop in intrapleural pressure, there is dyspnea, polypnea, thoracic pain and distress, cyanosis, and cough characterized by a thick mucopurulent discharge, the temperature ranges from 100 to 104° F., and the pulse may be as high as 160 per minute. The physical signs are variable As a rule the involvement is on the same side as the operation The chest is asymmetrical, percussion elicits dulness, and breath sounds are absent on the affected side Ordinarily the patient's condition is so serious as to prohibit the taking of x-rays, but when such an examination can be made, it reveals a displacement of the mediastinal structures and the heart to the affected side, an elevation of the diaphragm, and an increased density of the collapsed lung

The duration of the condition will depend upon the amount of lung tissue involved. If the lesion is localized and there is no infection, the mucus plug will be coughed up, and speedy recovery will follow within a few days If infection supervenes, however, pneumonia, pulmonary abscess, or pleurisy may develop, convalescence will be protracted, and, if the patient recovers, the lung will be left severely damaged Massive collapse may terminate fatally within a few minutes

(5) **Pulmonary Embolism and Infarction.** The lung is dependent for its nourishment mainly upon end arteries and has but a scanty collateral circulation. Therefore, when a branch of the pulmonary artery becomes obstructed by an embolus, the peculiar anatomic structure of the organ predisposes it to infarction and associated hemorrhage into the alveoli and surrounding interstitial tissues This condition is always a cause of great anxiety, since the obstruction of even a relatively small artery will prolong convalescence, while the plugging of a larger vessel may cause sudden death in a convalescing patient who is apparently out of danger Unlike the majority of pulmonary complications, which occur within the first to the fourth day after operation, embolism and infarction do not appear until the eighth to the fifteenth day Obviously the symptoms will vary in accordance with the location and size of the blood vessel involved If a small deep vessel is affected, as is usually the case, the respiratory impairment may be so slight as to produce no symptoms When a superficial vessel is involved, a small wedge-shaped infarct is formed which manifests itself by a gradual rise in temperature, an increase in pulse rate, interference with respiration, cough, expectoration, and cyanosis If a large vessel is obstructed, there results an immediate partial or complete pulmonary collapse characterized by a sudden onset

without premonitory symptoms, there is a sharp stabbing pain in the chest at the site of the infarct, the temperature and pulse rise abruptly, and dyspnea cough, and expectoration of a blood-streaked sputum soon supervene Physical examination of the chest reveals signs of solidification, with dulness, râles, tubular breathing, a pleural friction rub over the infarcted area, and shifting of the mediastinum X ray examination will disclose the site and extent of the lesion, the infarct usually appearing as a typical triangular shadow at the right costophrenic angle

If the embolus has lodged in a small vessel and is not infected, recovery is the rule but when it has plugged a major branch of the pulmonary artery, a considerable part of the blood supply to the lung is cut off As a result very little blood reaches the left side of the heart, the systemic blood pressure falls, the veins become engorged, and death may ensue from the strain put on the right side of the heart. It has been estimated that 25 per cent of patients so affected die within 10 to 20 minutes, another 25 per cent recover temporarily but succumb later to recurrence of the embolic phenomena, and the balance gradually improve and recover after a prolonged convalescence, although some permanent lung damage remains.

Management

Once pulmonary complications develop, their management becomes a medical problem and the patient had best be turned over to the internist. Their prevention, however, is a surgical responsibility, and the prophylactic measures have already been discussed (p 472) Briefly, they consist of avoidance of elective operations in the presence of respiratory disease improvement of oral hygiene for the purpose of decreasing the bacterial count of the buccal secretions, respiratory exercises and massage for the mobilization of the thoracic cage and the improvement of the diaphragmatic excursions, maintenance of nutrition an adequate water balance, and careful choice and administration of the anesthetic Local anesthesia is preferable, but if a general anesthetic is employed it is best administered endotracheally During anesthesia the upper respiratory tract is kept free of mucus, and just before the completion of the operation the patient is quickly de-etherized by means of inhalations of 10 per cent carbon dioxid-oxygen Precaution should be taken to avoid bruising and stretching of the tissues, and the body should be protected against chilling Tight abdominal dressings should be dispensed with as they force the abdominal viscera upward against the diaphragm and favor collapse of the lung Immediately after operation the patient is placed in the Trendelenburg position to facilitate the venous return to the heart, and later he is placed in the semi Fowler position to encourage lung expansion and increase the effectiveness of coughing

In the postoperative period measures should be taken to relieve pain as it discourages coughing and diminishes the respiratory excursions. Such analgesics should be chosen as will not depress the respiratory center If morphin is used, it should be administered in small doses to avoid interference with the cough reflex. Jackson (60) states "The cough reflex is the watch dog of the lung It seems strange that medical men should drug the watch dog asleep when his efforts are most needed. Morphine and heroine have indirectly killed thousands by the abolition of the cough reflex for every death that has resulted from their direct toxicity" *Atropin* is contraindicated, for

the hollow of the back also aids in the absorption of pressure Skin trauma will be minimized if the linen used is soft, pliable, and non-irritating, and if the bed is kept free from foreign particles Sheets should be drawn tightly across the bed to keep them free of wrinkles, and they should be changed frequently, especially when they become damp. The nutrition of the skin, particularly over bony prominences, should be maintained by washing the part with soap and water several times daily and thoroughly drying it with a soft towel The circulation is stimulated and the skin hardened by means of alcohol rubs, followed by the application of a dusting powder Finally, bony prominences are protected with strips of elastoplast

Once the skin has broken down, Latimer (67) advocates the use of tannic acid, applied in the same manner as in the case of a burn (p 318) Briefly, the area is sprayed every hour with a 5 per cent tannic acid solution and dried between applications either by means of an electrically heated cradle or an ordinary hair-dryer. The spraying is continued until a firm coagulum is formed—a process which requires from 24 to 48 hours Should infection occur beneath the crust, the latter is removed and the wound treated as outlined in the chapter dealing with burns Carty (21) advises that the granulations be protected against trauma by the application of strips of elastoplast, the material being kept in place until it separates spontaneously. The process can be repeated if necessary.

In the case of extensive lesions, if the general condition of the patient permits, he may be placed in a continuous bath kept clean and maintained at a constant temperature by a steady overflow. This expedient will provide uninterrupted drainage and relieve pressure

As soon as healthy granulations appear, the raw area is closed If the wound is narrow and surrounded by healthy tissue, the margins may be mobilized and united directly Otherwise, skin grafting must be resorted to

In addition to the local treatment, general measures should be instituted to improve the general nutrition Powers (89) advocates the administration of 5 units of insulin 3 times daily before meals

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CHAPTER X

THE CRANIUM

ANATOMIC CONSIDERATIONS

Scalp

The scalp extends anteroposteriorly from the supra-orbital ridges to the nuchal lines and laterally to the temporal ridges.

Layers. The scalp is composed from without inward of 5 layers (fig 210) (1) The *skin*, the thickest in the body and so firmly attached to the underlying aponeurosis of the epicranius (occipitofrontalis) muscle that the two structures can be separated only with the greatest difficulty This layer contains hair follicles and sudoriferous and sebaceous glands. It is the obstruction of the latter which causes the retention cysts or "wens" so commonly seen on the scalp (2) The *superficial fascia*, composed of short, dense, fibrous septa which enclose vessels, nerves, and lobules of fat. This layer is adherent to the skin above and to the galea below Owing to its fibrous arrangement superficial scalp wounds retract but slightly and infection does not tend to spread to the deeper layers of the scalp The fibrous septa attached to the blood vessels prevent their retraction, and in case of injury hemorrhage is apt to be profuse. The inelasticity of this layer permits of only limited swelling and in inflammatory states the exudate presses on the nerves and causes intense pain (3) The *epicranius (occipitofrontalis) muscle*, composed of an anterior and a posterior belly The anterior belly arises from the supra-orbital ridges and the posterior belly from the nuchal ridge. They pass upward for a distance of 5 cm. and are joined by a flat tendon called the *galea aponeurotica*, which covers the vertex of the skull. (4) *Subepicranial layer* A loose areolar connective tissue space containing emissary veins which communicate with the intracranial sinuses. This layer constitutes the "danger zone" of the scalp, since its loose structure permits of a rapid spread of infection, and the emissary veins form a ready pathway for the introduction of bacteria into the pachymeninx and sinuses. A wound penetrating into this layer especially one crossing the long axis of the muscle fibers, tends to gape widely due to the laxity of the tissues and the retraction of the divided epicranius. (5) The *pericranium* a thin, tough membrane, which strips easily from the bone, except at the suture line where it dips down to merge with the pachymeninx. This explains why effusions below the pericranium are limited by the suture lines.

Blood Vessels, Lymphatics, and Nerves. The blood supply to the scalp is abundant, and this accounts for the usual prompt healing of wounds in this region The lateral and posterior aspects of the scalp are supplied by the temporal, the posterior auricular, and the occipital branches of the external carotid artery while the anterior part is supplied by the frontal and supra-orbital branches of the ophthalmic. The veins

accompany the arteries and empty into the external jugular vein, with the exception of the emissary veins which drain into the superior sagittal (longitudinal) sinus, and the frontal and supra-orbital veins, which empty first into the ophthalmic veins and then into the cavernous sinus These two venous systems are of particular significance, as through them infection may be conveyed from the scalp and upper part of the face directly into the interior of the skull The lymphatics of the anterior scalp region empty into the submaxillary nodes, those of the lateral region into the posterior auricular nodes, and the posterior lymphatics into the occipital nodes The sensory nerve supply of the scalp is derived from branches of the trifacial, and the motor nerve supply from the facial

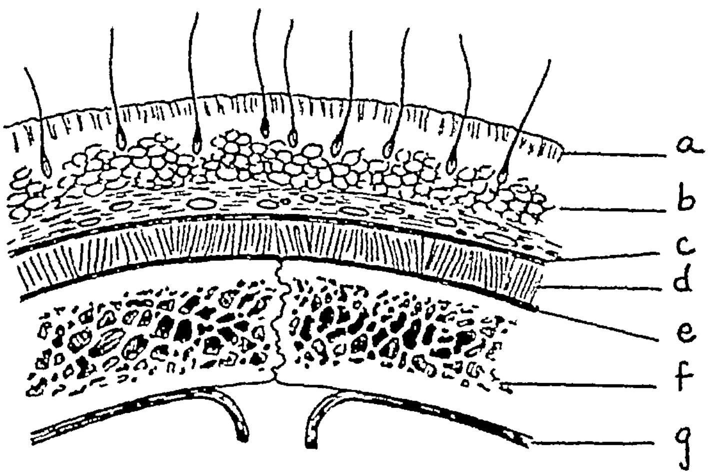

FIG 210 Sectional view of cranium *a*, skin *b*, subcutaneous tissue *c*, superficial fascia and galea aponeurotica *d*, subaponeurotic layer *e*, pericranium *f*, bone *g*, pachymeninx (Callander)

SKULL

The skull is composed of an outer and an inner table, between which is a vascular layer of cancellous bone, the diploe The outer plate is thick and elastic and covered by the pericranium Its density inhibits the entrance of infection, and this fact accounts for the rarity of osteomyelitis in this region following trauma The inner plate is thin and brittle It is grooved for the branches of the middle meningeal artery and is completely lined by the pachymeninx

The thickness of the skull is not uniform throughout, and this must be borne in mind in trephination The average thickness is 5 mm , but in the temporal region, over the sinuses, above the meningeal vessels, and at the anterior inferior angle of the frontal bone it is only 2 to 3 mm ; while in the region of the occipital, mastoid, parietal, and frontal bones it may be as much as 10 to 12 mm The thickness also varies in accordance with the age, sex, and race of the individual In childhood and old age it is relatively thin, due to the lack of diploe The skull of the male is thicker than that of the female and that of the Negro thicker than that of the Caucasian

The *blood supply* of the skull is derived from two sources: (1) a minor external supply from the small blood vessels of the pericranium, and (2) a major internal supply from branches of the meningeal arteries in the pachymeninx The bone is drained by three groups of diploic veins, a frontal group emptying into the supra-orbital vein, a temporoparietal group into the sphenoparietal sinus, and an occipital group into the lateral sinus

The skull is so constructed as to offer considerable resistance to violence. It is

somewhat protected by the thickness and density of the overlying scalp, and, architecturally, by its domelike contour it is enabled to disperse and absorb considerable force. Its many segments united by sutures permit of a certain amount of play and a momentary change in shape in response to trauma. Additional strength is afforded by the buttresses situated at the junction of the vault and the base. When these protective mechanisms are incapable of coping with the force, the bone gives way. As a rule, the inner plate suffers damage over a larger area than the outer, since (1) it has less support, (2) the force, being distributed over a smaller curve, is relatively greater (fig. 211), and (3) the traumatizing mass is larger, since in its passage through the outer plate it has accumulated bits of clothing and spicules of bone. Occasionally the external table alone is fractured or depressed and driven into the diploë. Conversely, the fracture may be limited to the inner plate, in which case there is apt to be

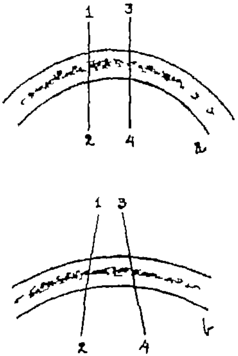

FIG. 211. Diagram, illustrating greater vulnerability of inner plate of skull to trauma. Force applied between lines *1–2* and *3–4* tends to force bones together at outer plate and separate them at inner plate, as shown in *b*. (Treves)

extensive splintering of the bone, owing to its relative thinness and brittleness. In children, where the bones are soft and elastic and the sutures relatively wide, the force may depress the bone without fracturing it.

Membranes of Brain

The brain is invested by two membranes, (1) the outer pachymeninx (dura mater), and (2) the inner leptomeninx (pia arachnoid).

Pachymeninx. The pachymeninx is a tough fibrous membrane whose outer surface is closely adherent to the inner surface of the brain case and serves not only to protect the brain but also as an endosteum to the cranial bones. It is so tightly attached at the base of the skull that extravasation of blood between the bone and the membrane is scarcely possible. It is this firm attachment which explains the frequency of dural

laceration in basal fractures In the vault, however, the attachment is more lax, except along the suture lines, and this looseness permits of the accumulation of fluids between the membrane and the bone, sometimes to such an extent as to cause compression of the brain The inner surface of the pachymeninx is separated from the leptomeninx by a potential cavity, the subdural space, which normally contains a small quantity of fluid for the prevention of friction arising from pulsation of the brain

At various points the pachymeninx encloses large venous channels called the sinuses of the dura mater. It also gives off four processes, only two of which need be mentioned at this time: (1) The falx cerebri which extends from the crista galli in front to the tentorium cerebelli behind and serves as a partition between the cerebral hemispheres In this septum is lodged the superior sagittal (superior longitudinal) sinus In the anterior cranial fossa this sinus communicates with the veins of the nose and the upper veins of the face by way of the foramen caecum. It also receives blood from the emissary veins, thus furnishing a direct communication between the brain and the scalp (2) The tentorium cerebelli, which spreads between the cerebrum and the cerebellum, and partitions off the posterior compartment from the two lateral compartments Its outer attached margin is convex and contains the lateral (transverse) sinus, which terminates in the internal jugular vein

The main *blood supply* to the pachymeninx is derived from the middle meningeal artery, a large branch of the internal maxillary. This vessel is one of great surgical significance, because it is the most frequent source of extradural hemorrhage Entering the cranium through the foramen spinosum in the floor of the middle fossa, it takes an upward course between the pachymeninx and the skull. It occupies a groove in the bone for a distance of 2 to 4 cm , then divides into two branches. The anterior branch is the larger, passing upward and across the anterior inferior angle of the parietal bone and along the great wing of the sphenoid The posterior branch runs backward across the squamous bone. A fracture over the region of the meningeal artery is invariably accompanied by a rupture of the vessel, since it is so deeply embedded in the groove in the bone that a fracture without laceration of the vessel would scarcely be possible Occasionally, a blow on the side of the head, not sufficiently forceful to fracture the bone, may cause a separation of the pachymeninx with a rupture of the vessel, the consequent accumulation of blood causing compression of the brain.

Leptomeninx. The leptomeninx is a delicate membrane situated beneath the pachymenix and composed of blood vessels and loose areolar tissue It consists of two layers The parietal or arachnoid layer is contiguous to the pachymeninx, and the visceral or pial layer invests the surface of the brain and cord, dipping into the fissures and sulci Over the venous sinuses this membrane gives off tufts or villi which probably aid in the absorption of the cerebrospinal fluid In adults some of these villi are arranged in groups known as pacchionian bodies Between the parietal and visceral layers is the subarachnoid space, which widens out at various points to form cisterns The most important of these is the *cisterna magna*, which lies in the angle between the cerebellum and the roof of the fourth ventricle. Another space termed the *lumbar sac* extends from the termination of the spinal cord at the level of the second lumbar vertebra to the second sacral vertebra Puncture at these sites permits of the withdrawal of the cerebrospinal fluid.

Cerebrospinal Fluid

The cerebrospinal fluid is contained within the subarachnoid space, the ventricles of the brain and the central canal of the cord In the skull it serves as a water-bed and acts in the capacity of a buffer for the protection of the brain against external violence and the effects of sudden changes in its circulation. Since the nervous system has no lymphatics, it is reasonable to assume that the cerebrospinal fluid also assists the brain in its efforts to expel the waste products of metabolism It ranges in specific gravity from 1 006 to 1 009 With the body in the lateral recumbent position the pressure is between 70 and 180 mm of water—i.e., roughly equal to the pressure within the veins. Any change in the venous pressure is followed by a corresponding alteration

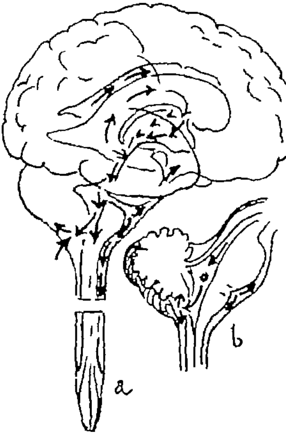

Fig. 212. Circulation of cerebrospinal fluid. Insert *b* shows cisterna magna. (Scarff)

in that of the cerebrospinal fluid. While the exact source of this fluid and the mechanism of its production are still matters of dispute, the majority of investigators are of the opinion that it originates in the choroid plexus, a network of pial vessels projecting beneath the ependymal lining of the ventricles (53) Some believe that it is directly secreted by the plexus (145) while others think it to be merely a dialysate from the blood plasma through the plexus (159)

The quantity of cerebrospinal fluid varies from a few cubic centimeters in infants to as much as 150 cc. in adults The total amount secreted daily is difficult to estimate, since all experimental investigations necessarily introduce a pathologic factor Masserman (150) computes the average amount at a little over 400 cc. a day A rise in venous pressure increases the quantity secreted, while the introduction of hypertonic solutions,

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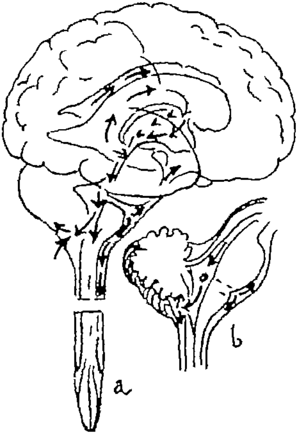

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by virtue of the resultant change in the osmotic pressure of the blood, decreases the amount

The cerebrospinal fluid does not "circulate" in the sense that any part of it returns to the point of origin After being secreted in the choroid plexus of the lateral ventricles, it flows into the third ventricle by way of the foramen of Monro From there it passes through the aqueduct of Sylvius into the fourth ventricle, thence through the two foramina of Luschka into the cisterna situated in the lateral recesses at the base of the brain, and from there into the cerebral and spinal subarachnoid spaces (fig 212) Any obstruction in its course results in hydrocephalus Just how the fluid is returned to the circulation has not been uncontrovertably established Key and Retzius (126) believed that it was absorbed into the venous circulation through minute openings in the pacchionian granulations, and this hypothesis is still generally accepted.

CRANIAL TRAUMATISMS

Head injuries are among the most common as well as the most alarming of major traumatisms, and their frequency is steadily rising, owing to the extension of mechanized industry and the increasing demand for greater speed in transportation It has been estimated that approximately 112,000 skull injuries occur annually in the United States, with an average mortality of 25 per cent (238) Because a large proportion of these injuries are the result of motor accidents, the majority naturally occur outside population centers According to Ramsdell (208), 64 per cent of patients so injured are admitted to small hospitals in rural districts Obviously, the immediate services of a neurosurgeon are seldom available in these localities, and the transportation of the patient to a place where such facilities would be at hand might endanger his life Furthermore, in the case of head injuries, it frequently happens that the time during which treatment can be administered to advantage is very brief Even a short delay may result in irreparable damage from a too prolonged anoxemia of the brain Because the responsibility for the care of these injuries frequently falls upon the general practitioner, it is essential that he be conversant with the fundamental principles underlying their management

Functional Pathology

The opportunity for an accurate correlation between clinical manifestations and pathologic changes taking place within an organ is afforded only by operation Since in traumatic brain injuries operative intervention is indicated in but a small percentage of cases, such a correlation has never been established Therefore, it is obviously impossible to ascribe a definite syndrome to the so-called contusions, lacerations, and edema of the brain Fortunately, such a differentiation is unnecessary for rational management It is generally conceded that the only factor which merits prognostic and therapeutic attention is the state of the intracranial pressure, and this can be determined by a more or less characteristic train of symptoms, which if analyzed and correctly interpreted, will supply all the information necessary to formulate an opinion as to what is going on within the skull

Head Injuries Unassociated with Gross Organic Changes in Brain

A minor injury to the brain is manifested by a temporary general depression of the central nervous system which for want of a better term is called "concussion" The

symptomatology is nearly identical with that of shock, and clinically the two conditions cannot be differentiated. About 25 per cent of head traumatisms are of this nature, and the mortality is estimated by Woodhall (257) to be 2.06 per cent.

Pathogenesis. The pathogenesis of concussion has never been clearly understood, since postmortem examination of the brain has failed to reveal consistently characteristic lesions. Many theories have been advanced to explain the mechanism. Some investigators believe that the sudden violence applied to the skull sets up vibrations in the brain which "mechanically" derange the nerve cells so as to effect a temporary interruption of the continuity of their connections. Indeed, the term concussion actually conveys the idea of vibration. Others maintain that with so profound a physiologic disturbance the condition must necessarily have an organic basis. They assume that the temporary in-bending of the elastic skull at the point where the force is applied traumatizes the brain and causes congestion, microscopic hemorrhages, edema, or multiple contusions, and that it is these pathologic alterations which are responsible for the clinical manifestations of concussion. In opposition to this theory it has been argued that organic changes would not be consistent with the generally evanescent character of the symptoms. Furthermore, examination of the cerebrospinal fluid discloses no alteration indicative of a pathologic change. The fluid is not found to be under tension, and it does not contain blood. Kocher (130) believed the condition to be the result of an acute compression, the force being transmitted through the brain but exerting its main effect upon the brain stem. Another hypothesis that has been suggested is that concussion is consequent upon a cerebral anemia. The sudden impact against the skull is presumed to set up a wave in the cerebrospinal fluid which stimulates the vasomotor centers in the medulla and thus causes a vasoconstriction. According to Duret (66, 67), it is the restiform body which is the specific site of this stimulation.

Clinical Features. The clinical features of concussion are principally of a cortical nature and consist of impairment of consciousness and interruption of motor and sensory activity. This may be attributed to the fact that the traumatizing force is usually applied to the vault, the brunt of the force being absorbed by the subjacent cerebral cortex. The brain stem with its so-called centers controlling circulation, respiration, and temperature is less likely to be affected by such trauma, because of its concealed position within the skull.

The onset of concussion is always sudden and is accompanied by a disturbance of sensibility ranging from momentary dizziness to complete unconsciousness lasting for several minutes. The face is pale and the surface temperature subnormal, the skin being cold and clammy. Appreciation of pain is diminished or entirely absent. The muscles are flaccid, but the reflexes, except in severe cases, are retained. As a rule the pupils are contracted but react to light, but in the case of serious damage they may be dilated and fixed. The body temperature tends to become subnormal. The pulse rate is not characteristic—it may remain normal, but is usually accelerated and the volume reduced. The blood pressure is lowered, the difference between the systolic and diastolic being as a rule less than 15 points. Respiration may be unchanged, or rapid and shallow.

Course. Ordinarily the patient regains consciousness within a few minutes and suffers no further complications, but since the absence of symptoms does not definitely preclude the possibility of brain injury, he should be kept quiet and under observation for several days. In some cases, upon the return of consciousness or after an apparently satisfactory recovery, the patient complains of headache, drowsiness, and vertigo, the

temperature rises to 101 to 102°F , and there is motor weakness, impaired memory, sensitivity to light, papilledema, and restlessness, a syndrome commonly referred to as "cerebral irritability" These manifestations are suggestive of beginning compression, the underlying pathologic state being attributed to congestion or edema of the brain They may either gradually subside or advance to the stage of profound coma, the clinical course depending upon the progress of the pathologic lesion In other cases the unconsciousness of concussion merges completely into the coma of compression, without any lucid interval It is then reasonable to assume the presence of a rapidly expanding intracranial lesion, such as hemorrhage from a large branch of the middle meningeal artery

Head Injuries Associated with Gross Organic Changes in Brain

Contusion and laceration of the brain following head injuries are accompanied by pathologic changes similar to those following injury to soft tissues elsewhere in the

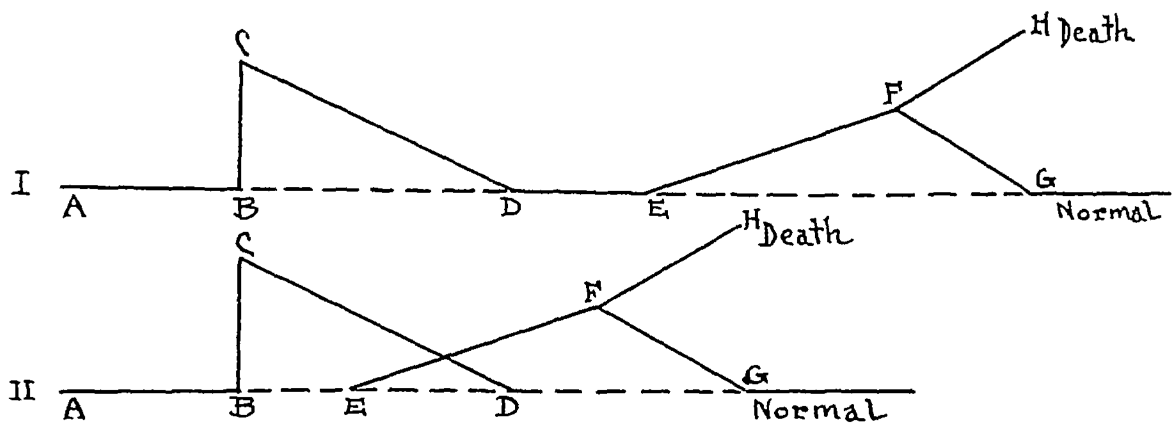

FIG 213 Diagram, illustrating relationship between concussion and compression *I, A–B–D–E–G,* normal level of consciousness, *B–C,* sudden onset of concussion, *C–D,* recession of symptoms, *D–E,* lucid interval, *E–F,* gradual onset of compression, *F–H,* medullary paralysis, *F–G,* recession of symptoms *II,* Triangle *E–F–G,* representing compression, overlaps triangle *B–C–D,* resulting in absence of lucid interval

body, and these changes, including congestion, extravasation, edema, and destruction of tissue, all have a tendency to increase the volume of the part But the brain, unlike other soft tissues, is enclosed in a case of bone which permits of only a limited amount of expansion of its contents Therefore, any expanding lesion will compress the brain and eventually cause interference with its function, manifested by a more or less characteristic train of symptoms

The time at which the symptoms of compression appear will depend upon the nature of the compressing force If its action is rapid, as follows a depressed fracture or a sudden profuse extravasation of blood into the cranial cavity, the symptoms appear at the time of the accident or soon thereafter, supplanting or overlapping those of concussion If the compressing factor acts gradually, as when blood is accumulating from the rupture of a small branch of an intracranial blood vessel, or when the brain is slowly enlarging from edema, there will be a longer lucid interval before the manifestation of the symptoms If the compressing agent is even more gradual in its formation, as,

for example, the accumulation of inflammatory or purulent exudates following meningitis, the symptoms may not appear for several days or even weeks.

The relation between concussion and compression following brain injury may perhaps be more clearly understood by a diagrammatic representation (fig 213) In I, line A–B–D–E–G represents the normal level of consciousness. Triangle B–C–D respresents concussion, B indicates the time of the injury, B–C, the sudden onset of concussion, and C–D, the more or less rapid recession of the symptoms to normal. Triangle E–F–G represents compression, E indicates the time of onset of the symptoms, increasing gradually from E to F The line F–H indicates uncompensated medullary paralysis followed by death F–G represents a gradual recession of the compression symptoms to normal. It will be seen from the above diagram that in concussion the maximum symptoms appear at the onset, as illustrated by the base of the triangle B–C while in compression the onset is gradual, as represented by the apex of the triangle E D–E indicates the period of consciousness between concussion and compression. In II, the symptoms of compression begin before the patient has recovered from concussion, so that the two triangles overlap without a lucid interval.

Compensated Intracranial Pressure It has been estimaed that 6 per cent of the intracranial space can be encroached upon without danger of serious disturbance of brain function. Two factors combine to make this possible (1) A diminution in the amount of cranial cerebrospinal fluid. As a result of the increased intracanial pressure, part of the cerebrospinal fluid will be displaced from cerebral to spinal distribution, and part will be reabsorbed into the circulation. (2) A decrease in the size of the vascular bed. The increased pressure within the skull stimulates the vasomotor center, which results in a reflex contraction of the blood vessels. This contraction automatically diminishes the size of the vascular bed, bringing about a relative increase in the size of the intracranial space and at the same time raises the intravascular pressure which serves to resist the compressing force. In this stage there may be no symptoms whatsoever, although patients sometimes complain of mental dulness or slight headache.

Compression with Venous and Capillary Stasis As the intracranial pressure continues to rise the cerebral blood vessels are encroached upon. The veins are the first to be affected, because their walls are thin and their intravascular pressure low, the latter being roughly equal to the pressure of the cerebrospinal fluid. The arteries, on the other hand are better constituted anatomically to resist moderate compression, as their walls are thicker and their intravascular pressure relatively high, being six times that within the veins As the veins are compressed, their contents are driven out of the cranial cavity, and the space thus created permits of a further accommodation for the increasing volume within the skull. Unfortunately, the compensation thus provided is only temporary since the venous stasis is soon followed by a rise in pressure in the choroid plexus. This pressure automatically increases the production of cerebrospinal fluid and in addition its absorption through the arachnoid villi is interrupted by the compression of the meninges against the skull.

The relative anoxemia of the brain stimulates the vasomotor center in the medulla and the vagus nerve bringing about a rise in systemic blood pressure and a slowing of the pulse. Owing to the venous stasis, the face is cyanosed the retinal veins are distended and tortuous, and the patient suffers from headache, vertigo, nausea and vomiting mental confusion, sensitivity to light, excitability and delirium

Compression with Cerebral Anemia. As the intracranial pressure approaches that of the diastolic blood pressure, the cerebral circulation becomes more and more embarrassed For a time, however, anoxemia of the brain is warded off by the compensatory vasoconstriction which leads to a rise in blood pressure sufficient to resist the compressing force In the words of Cushing (44): "An increase of intracranial tension occasions a rise of blood pressure which tends to find a level slightly above that of the pressure exerted against the medulla "

As the intracranial pressure continues to increase, however, a point will eventually be reached where the vasoconstrictors can compensate no further, and the arteries, being no longer able to resist the pressure, will be compressed Assuming that the resultant anemia is equally distributed, cortical symptoms will predominate over medullary. Since the cortex normally receives a rich blood supply and requires a large quantity of blood for proper function, even a slight deficiency will result in a disturbance of consciousness The medulla, on the other hand, normally receives but a scanty supply through the vertebral arteries, and is therefore better able to carry on its work, even after a rather considerable decrease in the volume of blood reaching it

In this stage of compression the symptoms will depend upon whether the pressure is diffuse, as in the case of a generalized cerebral edema, or local, as in the presence of a depressed fracture or a blood-clot It will be seen later that differentiation between generalized and localized pressure is of the greatest importance, since in the former instance operation is as a rule contraindicated, whereas in the latter immediate operation is imperative if the patient's life is to be preserved

(1) *Symptoms of Generalized Cerebral Anemia* The patient is profoundly unconscious The temperature rises to 101 to 103°F , the pulse rate drops to 40 to 50 per minute, there is a compensatory rise in blood pressure, due to the stimulation of the vasomotor center, the respirations are slow and stertorous, the pupils are fixed, being at first contracted and later dilated, the sphincters are relaxed and permit of involuntary evacuation of urine and feces Ophthalmoscopic examination made 5 to 6 hours after the injury may reveal tortuosity of the retinal veins, and after 24 hours obliteration of the normal optic cup by papilledema As long as the state of unconsciousness remains unchanged, the pulse regular and slow, and the temperature not above 103°F , medullary compensation is adequate, but any deepening of the coma, increase in pulse rate, or rise in temperature would indicate that the limits of medullary compensation have been reached

(2) *Symptoms of Localized Cerebral Anemia* If the compressing force is focal, the anemia will be limited to that part of the brain immediately underneath it. In depth the ischemic area is usually shallow, but its surface is comparatively extensive, owing to the pressure of the enlarged brain against the resistant skull. The gravity of such a lesion is dependent upon its location As has been previously stated, the cranial cavity is divided into three compartments, two anterior, partitioned off by the falx cerebri, and one posterior, separated from the two anterior compartments by the tentorium cerebelli If the compressing force is limited to the anterior compartments, there is no immediate cause for alarm Unfortunately, however, the pressure is sooner or later transmitted to the posterior or subtentorial compartment, where the danger is great, because here is situated the medulla with the respiratory, vasomotor, cardiac, and thermotactic centers Pressure in this locality forces the brain stem against the

foramen magnum, and should the aqueduct of Sylvius be encroached upon, the pathway of the cerebrospinal fluid from the third ventricle into the fourth will become obstructed and give rise to hydrocephalus above the tentorium, and this in turn will further increase the intracranial pressure Obviously, then, an expanding lesion originating in the posterior compartment is exceedingly grave from the very outset.

Naturally, the symptoms will be limited to the area innervated by the part of the cortex affected and will be most characteristic when the pressure is exerted on the cortical motor area The most familiar example of localized pressure in this area is hemorrhage from the middle meningeal artery At first the musculature on the side of the body opposite the lesion shows inco-ordinate contractions, but as the pressure increases, a flaccid paralysis develops. Early the reflexes are hyperactive but later they tend to disappear The pupil on the affected side is relatively large

Compression with Medullary Exhaustion. With a further increase in intracranial pressure the brain is forced down toward the base of the skull, and sooner or later the brain stem becomes compressed against the foramen magnum. When the intracranial pressure exceeds the systemic blood pressure, medullary anemia supervenes, and the nuclei which control circulation, respiration, and temperature become compressed. The patient lies in a state of profound coma, the respirations are rapid, shallow, and irregular, and frequently of the Cheyne-Stokes type, the temperature, previously high, begins to drop the pulse becomes weak and rapid, and may be imperceptible, the blood pressure falls, the pupils become dilated and fixed, the reflexes are abolished, the muscles are flaccid. Finally, the so-called vital centers become anemic, and death supervenes in from a few minutes to several hours

Diagnosis of Head Injuries

Violence applied to the head may damage the scalp, skull, or brain, or all three of these structures, and the appropriate treatment can be instituted only after a proper evaluation of the evidence obtained from (1) *a history of the accident*, (2) *a general physical examination* and (3) *a special examination of the head, including scalp, skull and brain*

History of Accident

A history of the circumstances surrounding the receipt of injury is of inestimable diagnostic value While a full account of the details is rarely obtainable, a few facts supplied either by the patient himself or by spectators may go far toward establishing the nature of the injury

State of Consciousness. Facts regarding the state of consciousness will help to determine whether or not the brain has been damaged If the patient is conscious, his power of orientation should be ascertained. If unconscious information should be sought regarding the onset and the duration of the unconsciousness and the presence or absence of a lucid interval

If loss of sensibility immediately followed the receipt of the head injury, it may be assumed to have resulted either from concussion or from a sudden increase in intracranial pressure, such as occurs in the case of hemorrhage from the middle meningeal

artery If the unconsciousness supervened more gradually, it is indicative of a slowly expanding lesion, such as the edema which follows laceration or contusion of the brain If the coma did not come on until days or weeks after the injury, it points to a collection of inflammatory or suppurative exudate The duration of the state of insensibility is roughly proportionate to the severity of the brain injury A short period followed by a rapid return to normal suggests a minor injury, while a prolonged coma or one with an incomplete recovery would indicate a more severe lesion The establishment of the presence of a lucid interval is of great diagnostic importance A history of unconsciousness followed by a lucid interval, and again supplanted by a lapse into unconsciousness presupposes compression due to intracranial hemorrhage

Nature of Force and Its Site of Application. A history of the nature of the force and the point at which it was applied will assist not only in furnishing important information regarding the head damage, but will also aid in determining the presence or absence of additional injuries to other parts of the body.

If the traumatizing agent was a small blunt mass, such as a hammer, delivered with a moderate velocity, a depressed fracture with local injury to the underlying brain is likely If it was a smaller mass, such as a bullet, traveling with great speed, extensive splintering of the inner plate of the skull and deeper penetration into the brain tissue is to be expected (p 558) Contact with a large mass of moderate velocity, such as occurs when the victim's head strikes against the ground after he has been thrown from a moving automobile, is likely to produce a bursting fissured fracture accompanied by "contrecoup" injury to the brain

The degree of force may be insufficient to fracture the skull and yet inflict severe damage upon the brain This phenomenon is explained on anatomic grounds As has been said before, the skull, because of its peculiar construction, differs from other bones in the mechanism of its reaction to violence Being an elastic cage, it is capable of a certain amount of yielding to a blow (p 521) At the point of impact a cone of depression is formed If the force has been insufficient to fracture the bone, the depressed area will immediately spring back into its original position, but even the momentary pressure on the brain caused by the temporary distortion may be enough to traumatize the brain tissue

Interrogation of witnesses as to the site at which the force was applied will often elicit information that will establish the type of fracture, indicate the part of the brain damaged, and suggest the probable complications For instance, a blow received on the vault may produce either a direct fracture of the underlying bone or an indirect fracture of the base, the latter being caused by the force transmitted down the vault and resulting in a compression of the base against the resistant spinal column Such a fracture is of the "bursting" type and occurs where thinner and thicker areas are contiguous and the degree of elasticity is slight A familiar example of this type of indirect fracture is that following a head-on dive into a shallow pool Similarly, a blow upon the chin may transmit the force along the condyles, driving them through the glenoid cavity and fracturing the middle fossa of the skull A fall on the buttocks may also fracture the base indirectly, the force transmitted by way of the vertebral column breaking the bone around the foramen magnum. An indirect injury of this type is well described by Fraser (88): "The roof of one of the large halls in Edinburgh was being redecorated, and a rope was passed from the upper scaffolding to the floor A

painter descended by it, and unfortunately his hands were slippery with oil, so that, instead of dropping gradually, he came down at a run and arrived at the floor of the hall in a sitting position. He apparently had some degree of concussion, but the jeers of his fellow workmen brought him to his senses, and he walked away Forty-eight hours later he was admitted to hospital with cerebral compression. He died, and necropsy revealed a fracture at the base of the skull encompassing the foramen magnum and passing into the posterior fossa." Basal fractures also occur as direct extensions of vault fractures. For example, fractures of the frontal region may spread to the anterior fossa those of the parietal region to the middle fossa, and those of the occipital region to the posterior fossa. The base may be fractured directly, in which case there will probably be a history of a foreign body, such as a stick, knife, or pencil, having been thrust through the roof of the orbit, or into the nostril, ear, or mouth.

The structures underlying the point of impact must always be given careful consideration. For instance a blow over the parietal region suggests hemorrhage from the middle meningeal artery over the supra-orbital region, involvement of the frontal sinus with its attendant danger of meningitis and pneumocephalus, and over the sagittal suture, hemorrhage from the dural sinus. If the force was applied to a brain area of known function, there is likely to be focal evidence of irritation or destruction of the site involved. Thus, a history of injury to the motor area not followed by focal phenomena, such as contralateral spasticity or flaccidity, warrants the assumption that the brain has not been damaged. On the other hand traumatisms to a "silent area" of the brain may inflict much damage without producing any symptoms.

General Physical Examination

A systematic, even if hasty, survey should always be made of the entire body for the detection of possible damage to other parts, since the severity of these injuries may be such as to demand treatment before those of the skull and its contents For example, attention to a thoracic or abdominal wound may be more urgent for the preservation of the patient s life than that to the craniocerebral injury Obviously, search for such associated lesions is especially important when the patient is unconscious and incapable of indicating their presence.

In the case of unconscious patients it is essential to exclude coma of non-traumatic origin Even in the presence of an obvious head injury the insensibility may be the result of apoplexy, drunkenness, uremia, diabetes, or some other general condition. An example of such a case has been cited by Fraser (88) A woman in the late sixties was admitted to my ward. She was deeply unconscious, there was a scalp wound in the right temporal region and a flaccid paralysis of the left arm and leg She had been found lying at the bottom of a common stair, and it was the impression of those who assisted her that she must have fallen and injured her head. In actual fact she was the victim of apoplexy and in this instance the head injury—if the scalp wound may be described as such—was *post hoc* to her unconsciousness."

Head Examination

As soon as the patient has recovered from shock, a detailed examination of the head is made. Usually the degree of cerebral damage is in proportion to the severity of

the scalp and skull injury It sometimes happens, however, that extensive lacerations of the scalp or even skull fractures are unassociated with cerebral damage, and conversely, widespread cerebral damage may be present with little or no external evidence of injury

The scalp is examined for contusions and lacerations If a wound is found, the surrounding parts are cleansed (p 270), and the wound margins are gently retracted, to establish the presence of foreign bodies, torn pericranium, and skull fractures Should a fracture be revealed, its position should be noted, lest it be confused with an oozing suture The condition of the bone is further investigated by palpation with a sterile-gloved finger Instrumental probing is to be avoided, for not only is such blind exploration of little diagnostic assistance, but it carries the danger of introducing infection into the cranial cavity. Firm pressure with the finger tips often elicits a painful response which may indicate a hitherto unsuspected fracture Care should be taken not to consider as traumatic a depression which is merely a natural peculiarity in the shape of the skull or a subperiosteal hematoma with a central indentation A hematoma can be distinguished by its elevation above the level of the skull, and its compressibility on firm pressure Roentgenographic examination, as will be seen later, may yield valuable information, but it is contraindicated at this stage of the investigation

The nose, mouth, and auditory canal should be inspected for evidences of hemorrhage or discharge of cerebrospinal fluid. An escape of the latter through any of these orifices indicates that the fracture is compound with concurrent injury to the brain coverings or to the brain itself

Since basal fractures necessarily include the foramina at the base of the skull, involvement of the cranial nerves emerging from these apertures is frequently a concomitant feature If the nerve damage is the result of laceration, it manifests itself at once, but if it is due to pressure of a hemorrhagic or inflammatory exudate into the nerve sheath, it may not become evident until later The nerves affected are the first, third, fourth, sixth, seventh, and eighth, the last two being the ones most commonly injured. Involvement of the first, seventh, and eighth leads to the most serious consequences, because of their relation to the nasal fossa and the auditory canal

If a basal fracture has been diagnosed, it is important from a prognostic standpoint to determine its location Fractures involving the anterior fossa are not immediately dangerous, but owing to the relation of this area to the frontal, sphenoidal, and ethmoidal cells, the nasal fossa, and the orbit, late infection is likely Fractures of the middle fossa carry the immediate danger of injury to the hypophysis and the later threat of infection from the ear Those of the posterior fossa are always hazardous because of the proximity of the fossa to the vital centers of the medulla, they are, however, relatively free from the risk of secondary infection

Fracture of the anterior fossa is manifested by an escape of blood and cerebrospinal fluid from the nose, with or without subconjunctival ecchymosis There is also an involvement of one or more of the first six cranial nerves, the sixth being the one most commonly injured The middle fossa, owing to the thinness of the bone in this location, is the part of the base most subject to fracture, the line passing through the sphenoid bone, the base of the occipital bone, or the petrous portion of the temporal bone Due to the proximity of the fracture to the acoustic canal, there is usually hemorrhage from the external ear, occasionally, however, the blood follows the eustachian tube and

escapes by way of the nose or mouth, or it may be swallowed and subsequently vomited. If the blood is admixed with cerebrospinal fluid, it indicates an associated rupture of the pachymeninx. Fractures in this area usually involve the seventh and eighth cranial nerves, evidenced by paralysis of the facial muscles, vertigo, tinnitus and impairment of hearing. In fracture of the posterior fossa there is pain on pressure over the mastoid process. If the basilar process of the occipital bone is broken and the pharyngeal mucosa torn, the blood escapes into the pharynx, but in the absence of mucosal lacerations, it finds its way into the soft tissues of the occipital scalp. Involvement of the midbrain or brain stem gives rise to the characteristic picture of decerebrate rigidity.

Roentgenographic Examination. Roentgenographic examination of the skull should never be omitted, since the findings serve as a record for the legal protection of the patient, the surgeon, and the hospital, and furnish valuable information from a prognostic and diagnostic standpoint. Roentgenograms cannot, however, be relied upon to indicate the amount of brain damage, since, as has been previously stated, extensive skull fractures may be associated with little cerebral injury, and, conversely, extensive brain damage may be present even in the absence of fracture. Moreover, they are rarely helpful in demonstrating basal fractures, with the exception of those which are continuations of fractures of the vault.

While the value of roentgenography is conceded, it is best postponed until the patient has fully recovered from shock and his condition will safely permit of the necessary manipulation, inasmuch as all the required information upon which to base the early treatment can be obtained from the clinical findings. The only justification for early examination is in the case of a suspected hemorrhage from the middle meningeal artery. Here the disclosure of a fracture crossing the path of the middle meningeal artery will often substantiate the clinical diagnosis and assist in determining the advisability of operative intervention.

The examination should include stereoscopic views of each side of the skull, as well as anteroposterior and postero-anterior views to show the foramen magnum and the frontal bone. In the interpretation of the findings, normal middle meningeal markings should not be mistaken for hair line fractures, nor should the remains of an old skull fracture be mistaken for a recent one.

Spinal Puncture

There is some disparity of opinion among surgeons concerning the value of lumbar puncture as a diagnostic procedure. Some believe it to be of great value (121), while others condemn its routine use. Dandy (52) states: "Lumbar punctures are far too dangerous to be offered as a diagnostic aid, particularly when they offer almost nothing of value in diagnosis.

While it is true that lumbar puncture will reveal the presence of blood in the cerebrospinal fluid and will indicate the degree of pressure, nevertheless, the disturbance occasioned the patient by such a procedure does not ordinarily warrant its use, especially since all the information necessary for the establishment of a diagnosis can be obtained by inspection, palpation and a correlation of the clinical features. Moreover, there is a possibility that the lumbar puncture may further disturb the intracranial pressure balance. Finally, the findings obtained by spinal puncture may be misleading in that

they may fail to disclose the exact degree of intracranial pressure—for example, in the case of partial or complete blockage of the cerebrospinal pathway, the spinal pressure may be low and the intracranial pressure high Spinal puncture is, however, justifiable in cases of head injury where doubt exists as to whether or not the brain has been damaged Under such circumstances, the finding of blood and a cerebrospinal fluid pressure above 180 mm of water may help to corroborate a tentative diagnosis of brain injury

Estimation of Brain Damage

An estimation of the brain damage and of the degree of physiologic compensation can be obtained only from a careful study of the following clinical signs: (1) the state of consciousness, (2) the pulse, (3) the temperature, (4) the respiration, (5) the blood pressure, (6) the pupillary reactions and eye-grounds, and (7) the muscles and reflexes. Taken singly, the above factors have little significance, but a painstaking correlation of the collective manifestations will usually furnish information as to the nature of the intracranial injury Thus a gradual rise in blood pressure accompanied by a drop in the pulse rate and a deepening unconsciousness is pathognomonic of increasing intracranial pressure

Following brain injury the pathologic process within the cranium is likely to change rapidly For this reason examinations should be made at the moment of the patient's admittance, and the findings for the first 24 hours should be recorded at half-hour intervals Only by means of these recordings can the progress of the brain injury be accurately estimated, danger signals detected, and appropriate treatment instituted

State of Consciousness. An estimate of the depth of unconsciousness is the most reliable single sign in the establishment of the extent of the cerebral injury and the advance or regression of the pathologic process It is reasonably safe to assume that the more profound the coma, the more serious the brain damage If the insensibility is deepening, it indicates an increasing intracranial pressure, if, on the other hand, it is becoming less profound, the intracranial pressure is probably diminishing The state of consciousness may be roughly determined by the patient's reaction to stimuli If he offers a reply to a simple question spoken in an ordinary tone of voice, it points to slight injury If he does not respond to a forcible command spoken in a loud voice and his reflexes remain intact, it would suggest moderate brain damage Failure to react to a painful stimulus, such as the non-withdrawal of a part when the skin is pinched, accompanied by a loss of reflexes, is indicative of serious cerebral damage

Brief periods of restlessness and excitability following unconsciousness may indicate the onset of recovery If, however, these symptoms persist or supervene after a lucid interval, they suggest meningeal irritation, probably due to hemorrhage into the subarachnoid space If these symptoms are associated with a rise in temperature and pulse rate, laceration of the brain may be assumed.

Pulse. The pulse rate affords valuable information. A rapid pulse—between 140 and 180—of small volume, but quickly readjusting itself to normal, would indicate concussion A decreasing pulse with an increasing volume, especially when accompanied by a deepening unconsciousness, suggests vasomotor stimulation and beginning compression As long as the pulse rate remains slow but keeps above 40 per minute and is regular and of full quality, physiologic compensation is taking place But if

the rate increases to 120 or above, or drops below 40, especially if the change in rate is sudden and accompanied by a decrease in volume, it signifies the onset of medullary paralysis.

Temperature. Following head injury a subnormal temperature which returns to normal as the patient regains consciousness is indicative of concussion. If the temperature continues to rise, cerebral damage should be suspected, and the greater the elevation the more extensive the injury An increase in temperature up to, but not above, 103 degrees is suggestive of compression with medullary compensation, but an elevation above this point, especially if associated with deepening of the coma, is a grave prognostic omen as it heralds the approach of medullary paralysis If the patient has suffered a compound skull fracture, and the elevation of temperature appears 3 or 4 days after the accident and is associated with impairment of consciousness it points to compression due to infection of the meninges or brain.

Respiration. The significance of respiration in the estimation of brain damage is subject to dispute. While Fay (77) believes that the rate and character of the respirations furnish a reliable and important index to the extent of intracranial injury, others maintain that they are of little diagnostic value. As a rule, rapid and shallow breathing with a more or less rapid return to normal indicates concussion. If the respirations are slow and uniform, they suggest compression, and if irregular—especially if of the Cheyne-Stokes type—they presuppose medullary encroachment and disturbance of the respiratory center

Blood Pressure. The value of blood pressure is also subject to a difference of opinion Cushing (43) believes it to be a significant indicator of the progress of events in the skull and wrote "The extent of this rise in blood pressure may be taken as an indication of the degree of advancement of the compression." On the other hand, Dandy (52) states "The blood pressure usually regarded as an important index I have found to be of little value." Generally it may be assumed that a drop in blood pressure followed by a rise to a few points above normal, with a subsequent readjustment to the individual's average is an indication that the cerebral damage is slight. But if after the preliminary fall the pressure rises to a high level and remains there, increased intracranial pressure should be suspected. If the heightened pressure begins to fall and is accompanied by a deepening of the coma, it suggests medullary encroachment.

Fay (81) believes that the pulse pressure is the most important index to the severity of the brain injury The normal pulse pressure is 40 mm of mercury, when it approaches 50 or 60, he considers it a sign of increasing anemia of the brain, and when it falls to 30 or below he believes that vasomotor failure is imminent.

Pupillary Reactions and Eye-Grounds. If the pupils are moderately contracted or dilated yet react normally to light, the underlying lesion is probably not a severe one. Moderately contracted pupils, reacting sluggishly, suggest cerebral compression. Dilated pupils which fail to respond to light are indicative of beginning medullary paralysis. If but one pupil is affected especially in the presence of an associated contralateral hemiplegia it presupposes a unilateral lesion on the same side as the pupillary involvement. The underlying pathologic condition is usually hemorrhage from the middle meningeal artery, the clot being on the same side as the affected pupil.

After the first 24 hours a study of the eye-grounds may furnish useful information. This examination should be carried out by a trained ophthalmologist. The finding

of retinal hemorrhage suggests subarachnoid bleeding, while a unilateral obliteration of the optic cup by a papilledema points to a brain lesion on that side.

Muscles and Reflexes The muscles should be examined for evidences of twitching, flaccidity, and spasticity. Spasticity followed by flaccidity of the muscles on one side indicates involvement of the cortical motor area on the opposite side In cerebral compression the plantar, abdominal, and other tendon reflexes become disorganized early, and therefore it is inadvisable to place any definite reliance upon their reactions

Diagnosis of Intracranial Hemorrhage

Intracranial hemorrhage is comparatively rare, occurring in only 3 to 5 per cent of head injuries Nevertheless, when it does take place, it is of the utmost importance that it be diagnosed at the earliest possible moment, since immediate operation is the only means of saving the patient's life If it is not recognized until the patient has lapsed into a profound unconsciousness, the brain may be so damaged by the pressure of the blood-clot that operation will be of no avail

Intracranial hemorrhage may originate either above or below the pachymeninx *Extradural bleeding* is almost invariably due to rupture of the middle meningeal artery, although in rare instances it arises from the venous channels lying in the diploe Irrespective of the origin of this type of hemorrhage, the extravasated blood dissects between the pachymeninx and the skull, and when the clot has reached a sufficient size to cause pressure on the brain, symptoms appear If the rupture is associated with a compound fracture, some of the blood may escape externally, in which case there is less danger of its pressing upon the brain tissue

Hemorrhage from the middle meningeal artery is suggested by a history of trauma in the vicinity of the artery and a syndrome characterized by (1) an immediate loss of consciousness, succeeded by (2) a temporary lucid interval, due to recovery from the initial concussion, and (3) a secondary lapse into unconsciousness, owing to compression of the brain by the extravasated blood The lucid interval between the primary and secondary periods of unconsciousness may last from a few minutes to several hours, depending upon the rapidity and quantity of blood exuding from the damaged vessel During the primary coma, because of the low blood pressure characteristic of concussion, active hemorrhage is not marked, but upon the return of consciousness the rise in the pressure promotes more active bleeding Sooner or later the clot reaches such proportions that consciousness can no longer be retained, and within 2 or 3 hours the patient's condition becomes desperate

The site of hemorrhage is frequently suggested by the motor symptoms The muscles on the side of the body *opposite* the hemorrhage show a paresis or spasm resembling the jacksonian type of convulsions The slightest contralateral paresis or spasm beginning in the face and tending to extend to the upper or lower extremity should raise the suspicion of hemorrhage of a progressive nature Another significant symptom is a unilateral dilatation and fixation of the pupil on the affected side (115) According to Rand (209), if the dilated pupil is on the same side as the hemiplegia, there is a local bilateral brain injury Corroborating evidence of the source of hemorrhage can likewise be obtained from roentgenographic examinations, which may reveal a fracture line across the groove of the middle meningeal artery

When the characteristic syndrome of middle meningeal hemorrhage is present, and

localizing signs are evident, the diagnosis is obvious, but unfortunately these distinguishing features seldom exist in their entirety, so that early symptomatic diagnosis is rarely possible. Therefore, if the clinical picture is inconclusive but intracranial hemorrhage is suspected, a diagnostic exploration should be made to substantiate the diagnosis, in view of the urgent need for early surgical intervention The procedure consists in removing with a trephine a small section of bone from the temporal region (fig 214) The presence or absence of a blood-clot will verify or disprove the tentative diagnosis. If no blood-clot is discovered, the pachymeninx should be examined If the latter is found to be under increased tension, there is reason to suspect subdural hemorrhage, and an incision should be made over the point of bulging Should the investigation of one side prove negative, the button of bone is replaced, the wound closed, and a similar exploration made on the opposite side.

Subdural hemorrhage follows rupture of vessels of the leptomeninx or cortex and may be diffuse or localized arterial or venous, superficial or deep The diffuse form is of interest merely from a pathologic standpoint, since the outcome is invariably fatal. In the case of local arterial hemorrhage the bleeding is apt to be rapid and give rise to symptoms of pressure at an early stage. In venous hemorrhage, however, since the venous pressure is only slightly higher than the intracranial, the escape of blood is gradual and therefore clinical signs often do not appear until days or even months after the hematoma has become organized or encysted. The dural sinuses are seldom torn, unless the fracture lies directly over them and even then gross hemorrhage from the torn sinus may occur only after the bone fragment has been elevated. When the superior longitudinal sinus is involved, the lesion is manifested by a bilateral rigidity of the muscles, convulsive seizures, elevation of temperature and unconsciousness. If the injury is located in the posterior part of the sinus, death quickly supervenes from pressure on the medulla. Superficial hemorrhages into the cortex are usually multiple and cause no increased intracranial pressure, though a rise in temperature, pulse, and respiration, mental confusion, restlessness, and spasticity of the muscles will be in evidence Occasionally, the bleeding is deep, involving the basal ganglia, and in such cases it superinduces the so-called traumatic encephalitis, a condition resembling a mild concussion and differing from it only by its prolonged duration.

Management of Head Injuries

The management of head injuries with the exception of those complicated by brain damage, does not differ materially from that accorded injuries elsewhere in the body (p 265)

GENERAL TREATMENT

Shock (Concussion)

Since shock or concussion accompanies the majority of severe head traumatisms and is an immediate menace to the life of the patient attention to this condition naturally takes precedence. The treatment is for the most part symptomatic and observative, and is outlined in detail on page 388 All local treatment of the head injury is postponed until the patient has recovered from shock A compound fracture of the skull,

if present, is merely covered with a sterile dressing, no attempt being made at this point to sterilize the wound or to remove foreign bodies. If there is bleeding from the ear and nose, the patient is turned on his abdomen and the affected orifices covered with sterile dressings. Syringing, douching, and packing are contraindicated, since these procedures may drive infection into the cranial cavity. Examinations, such as roentgenography and lumbar puncture, should be omitted in this stage, as they only aggravate the shock. Dandy (52) states that a patient who will not survive a period of 4 to 6 hours of observation will not recover, regardless of the treatment he receives. The only justifiable interference at this stage is the care of an urgent visceral lesion, the temporary splinting of a fractured limb, or the control of hemorrhage.

The body temperature is maintained by means of hot-water bottles and warm blankets. A close watch should be kept on the action of the bladder and bowels. As a rule, catheterization will be required during the first 24 to 48 hours. The low blood pressure common in connection with intracranial injury is combated in the same manner as that due to shock from other causes, except that stimulants and fluids must be used with greater caution, since here the low blood pressure serves temporarily as a physiologic compensation for the increased intracranial pressure. To maintain the failing circulation, drugs, such as caffein sodium benzoate 0.5 gram ($7\frac{1}{2}$ grains), camphorated oil 2 grams (30 grains), or adrenalin 0.3 to 0.6 gram (5 to 10 grains), may be given hypodermically when indicated, but more intensive stimulation, such as is used for ordinary shock, should be avoided, as it may augment the intracranial pressure and bring about a recurrence of hemorrhage.

Isotonic solutions may be administered, but to avoid the danger of cerebral edema they should be given in small quantities. Hypertonic solutions are inadvisable in the presence of a normal blood volume, since they tend to bring about a further drop in the already low intracranial pressure and thus interfere with the tendency toward physiologic compensation. However, when the blood volume is low, intravenous injections of hypertonic glucose in amounts of 50 to 150 cc. of a 50 per cent solution will prove advantageous. If there has been considerable hemorrhage, the injection of 250 cc. of properly matched citrated blood may be of benefit. In the absence of a suitable donor, the intravenous administration of 200 to 500 cc. of a 6 per cent gum acacia solution will serve the same purpose.

Pain and restlessness are controlled by the application of ice bags to the head and the administration of sedatives, those most frequently employed being sodium luminal 0.1 to 0.2 gram (2 to 4 grains), chloral hydrate 1 to 1.3 grams (15 to 20 grains), or potassium bromid 1 to 1.3 grams (15 to 20 grains), given orally and the dose repeated every 3 to 4 hours if necessary. If the patient is unable to swallow, hyoscin hydrobromid may be given hypodermically in a 0.0003-gram ($\frac{1}{200}$ grain) dose, or paraldehyd 15 grams ($\frac{1}{2}$ ounce) in 120 cc. (4 ounces) of water rectally once or twice daily. Morphin should be withheld, since it depresses the already embarrassed circulation and induces venous congestion, which has a tendency to increase the cerebrospinal fluid pressure and bring about a deepening of the coma. An additional objection to its use is that it contracts the pupils and masks the state of consciousness, making it difficult to judge whether the impaired sensibility and contracted pupils are the result of the cerebral injury or due to the effects of the drug. However, if the restlessness can be controlled in no other way, morphin is preferable to physical restraint. As a safeguard against

infection the oral administration of 0 6 to 1.3 grams (10 to 20 grains) of hexamethylenamin 4 times a day has been suggested because of the fact that it is excreted in the cerebrospinal fluid and is said to possess antiseptic qualities

While the treatment of shock is being instituted, careful ¼-hourly observations are made of the state of consciousness, pulse rate, temperature, blood pressure, and respiration. Daily records should be kept of the fluid intake and output the neurologic findings, blood count, and blood chemistry to determine the progress of the cerebral damage and furnish a guide for further treatment.

When the patient has recovered from shock—usually within 24 hours—a detailed examination and roentgenographic investigation of the head injury is made. The scalp wound is treated (p 549) and fractures, if present, attended to (p 552) If the condition is satisfactory, all that will be required aside from the above-mentioned local treatment, are rest and watchful care. The patient is placed on a light diet, and

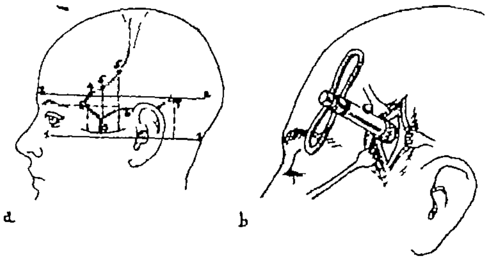

FIG 214. Exploration to substantiate tentative diagnosis of hemorrhage from middle meningeal artery *a* craniocerebral topography *1 1* horizontal line through infra-orbital margin and acoustic canal (Reid's base line) *2 2* line parallel to *1 1* at level of supra-orbital margin. *3* middle meningeal artery *4* anterior branch. *5 5 5* three sites for trephining. *6* posterior branch. *7*, site for trephining. *b* linear incision made over temporal region muscle separated and retracted, and button of bone removed with trephine at point 5 cm. behind lateral angular process of frontal bone and 5 cm. above zygoma. (Rawling)

his fluid intake is restricted to 1500 cc daily On the second or third day he receives by mouth 60 to 90 cc. (2 to 3 ounces) of a 50 per cent solution of Epsom salts to clear the bowels. It is well to keep him in bed for 10 days or longer, depending upon the severity of the injury Experience has shown that failure to enforce this period of rest is frequently followed by such posttraumatic sequelae as headache, giddiness, impairment of attention, change in behavior, and disturbance of memory A further advantage of a prolonged stay in bed is that it affords an opportunity for observation of the patient, since there is never any certainty that hemorrhage inflammation, or infection may not supervene

Compression

If the concussion is followed by a deepening unconsciousness, a slowing of pulse and respiration, a rising blood pressure, and an elevation of temperature, it is evident that

the intracranial pressure is rising to a dangerous degree This pressure must be reduced, otherwise, the oxygen deprivation may cause irreparable brain damage The method to be adopted will depend upon the nature of the compressing force (1) If it is due to intracranial hemorrhage, an immediate operation is required for the control of the bleeding (2) If, on the other hand, the pressure is the result of a progressive edema or congestion following contusion or laceration of the brain, the indication for its relief is less urgent In such cases the choice of management will lie between (a) palliative measures, such as dehydration and spinal drainage, and (b) radical decompression

(1) Treatment of Intracranial Pressure Due to Middle Meningeal Hemorrhage. If the intracranial pressure is being caused by the extravasation of blood from the middle meningeal artery, immediate operation for the removal of the blood-clot and the control of hemorrhage is imperative The details of the technic for the scalp incision, exposure, and removal of the bone are the same as those for any subtemporal decompression (p 545) Approach to the bleeding vessel may be gained through a linear incision over the temporal region The muscle is retracted and a button of bone removed with a trephine at a point 5 cm behind the lateral angular process of the frontal bone and 5 cm. above the zygoma (fig 214) The blood-clot which has caused the compression will at once be visible and is evacuated by irrigation and suction The part is then inspected for evidence of active hemorrhage, which, if found, is immediately attended to If the hemorrhage originates in a vessel adherent to the surface of the pachymeninx, it is ligated with an underrunning suture or coagulated by diathermy Should the ruptured vessel lie in a groove in the bone, it is either plugged with Horsley's wax or compressed against the bone Bleeding from the middle meningeal artery at the point of its emergence from the floor of the skull at the foramen spinosum is checked by packing the aperture with wax Should the above methods fail to control the hemorrhage, ligation of the external carotid artery must be resorted to After the blood-clot has been removed and the bleeding checked, the scalp wound is closed in layers with fine silk sutures (p 69). In a large percentage of cases the above procedure will bring about an improvement in the patient's general condition, and no further intervention will be necessary

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(c) Hypertonic solutions, when administered intravenously, render the blood tonic and the blood, in an attempt to regain its isotonic balance, abstracts from the body tissues. The brain in common with other tissues releases its f hence its volume is reduced. Following the experimental demonstration by (251, 252) and his associates that these solutions were capable of reducing the the brain, their use was for a time widely advocated. The first agent exp with for the purpose was a hypertonic solution of sodium chlorid. It was sc covered, however that its beneficial effect was but temporary, and that there fc a secondary rise in intracranial pressure. The latter phenomenon is explained

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logically by the fact that in the process of dehydration the salt is dialyzed through the cell membrane and becomes fixed in the brain tissue which, as a result, becomes hypertonic The temporarily dehydrated brain, containing an excessive amount of fixed sodium chlorid, will, in an effort to regain its isotonicity, automatically abstract fluid from the blood As a result, there will supervene a secondary edema, which is said to be more serious than the original Another objection to the use of hypertonic sodium chlorid solution is its crenating effect upon the red blood cells Because of these disadvantages it was discarded in favor of hypertonic glucose solution.

Glucose, when given in amounts of 50 to 100 cc of a 50 per cent solution, was found to cause a rapid shrinkage of the edematous brain, but unfortunately its administration was also followed by a secondary increase of intracranial pressure Indeed, Jackson (119) and others assert that the use of hypertonic glucose results in an immediate increase of pressure in half the cases and a secondary rise after 15 to 20 minutes in all cases

Bullock (30), in an effort to overcome the secondary edema of the brain following the use of hypertonic sodium chlorid and glucose solutions, experimented on animals with a 50 per cent solution of sucrose It was found that after the intravenous injection of 100 to 500 cc of this solution at the rate of 5 cc per minute there was a reduction of from 25 to 100 per cent or more in the intracranial pressure—a result equally as good as that obtained with glucose, and without an objectionable secondary rise in pressure or toxic effect. The absence of this secondary rise is attributed to the fact that sucrose, due to the larger size of its molecule, does not penetrate the blood cerebral barrier as does glucose Therefore its introduction brings about no change in the osmotic tension of the brain tissue and occasions no need for a secondary readjustment of its fluid content Thus secondary edema with its associated rise in pressure is forestalled Masserman (151), working on human subjects, found that 50 per cent hypertonic sucrose given intravenously in amounts of 300 to 500 cc effected a reduction of intracranial pressure of about 37 per cent lasting for a period of 2½ to 5 hours, and that the amount of fluid excreted was equivalent to 4 times the quantity injected He also observed that there were no toxic symptoms and no crenation of blood cells The only objectionable reactions occasioned were thirst, malaise, pain in the muscles, and a moderate leukocytosis No fixed rules as to the administration of sucrose solution can be formulated, the percentage and quantity must be regulated by the case under consideration Ordinarily a 25 to 50 per cent solution is given intravenously in amounts of 100 to 300 cc at the rate of 5 cc per minute

Dehydration for the reduction of intracranial pressure has lost considerable popularity in recent years because of its many secondary ill effects Woodhall (257) believes that the osmotic disturbance produced by the dehydration may result in further damage to the already traumatized brain tissue, thus "adding insult to injury" Coleman (37) states "In my own experience with dehydration it was found that if dehydration was carried to the extent where fluid was removed from the brain in sufficient amount to cause marked reduction of intracranial pressure the condition of the patient was made worse rather than better" Dandy (52) also feels that recourse to hypertonic solutions is inadvisable On the other hand, surgeons of equal authority advocate its use and believe it to be one of the most efficacious agents for the reduction of intracranial pressure (80)

While there is no question that dehydration is capable of reducing the intracranial pressure and that in selected cases it has a definite therapeutic value, the indiscriminate

routine use of this method is to be condemned. For edema unassociated with extravasation and in the absence of shock or hemorrhage it is often employed with benefit. In the presence of shock, however, dehydration is contraindicated, since it causes a further depletion of the fluids required by the blood. Its use should also be avoided in hemorrhage, especially if the bleeding is recent, since it is apt to disturb the blood-clot and bring about a renewed blood loss.

Spinal Drainage. The advisability of recourse to spinal drainage for the reduction of intracranial pressure is open to the same division of opinion as the question of dehydration. There are some who consider it of great value and adopt it as a routine measure (23, 231), and others who believe its benefits, if any, are too limited to justify its use (254, 142, 224, 36) The advocates of spinal drainage hold that by means of repeated punctures a reduction of intracranial pressure can be maintained for several days and the body be given an opportunity to re-establish physiologic compensation and thus offset the detrimental effects of the increased pressure. They also assert that by this procedure the cerebrospinal fluid is freed of irritating blood constituents which if allowed to remain would either obstruct the villi and interfere with absorption (251, 78), or give rise to a pia arachnoiditis or some other posttraumatic sequela (122, 8 178, 182, 180)

The opponents of spinal drainage, on the other hand, express the view on clinical grounds that physiologic compensation is not possible through spinal puncture and that the quantity of blood that can be withdrawn by this procedure is so small as to be of no benefit. Sprong (236) showed that even repeated punctures removed only 2 to 5 cc. of blood, irrespective of the amount in the spinal fluid. The opponents of this method also emphasize the fact that it is not without danger They point out that the sudden fluctuation in intracranial pressure may inflict additional trauma upon the brain, that the unavoidable disturbance of the patient may induce shock or aggravate it if already present, and finally, that the sudden release of pressure within the spinal canal may result in a medullary herniation into the foramen magnum.

Like dehydration, spinal drainage, if used indiscriminately, may do much harm, and as a routine procedure it is to be condemned. It is contraindicated in the case of shock because the manipulation involved offsets any possible benefit. It should be avoided if extradural hemorrhage is suspected, inasmuch as the sudden reduction of pressure may release a blood-clot and thus precipitate a recurrence of the bleeding Some believe, however, that these ill effects can be forestalled by a gradual lowering of the pressure to no more than half of its original level. Spinal drainage should not be resorted to in compound fractures of the skull. In vault fractures the resultant reduction of intracranial pressure may allow infectious material to be drawn from the fractured area into the cranial cavity In basal fractures there is the added danger that such material may be forced into the spinal subarachnoid space. Finally, spinal drainage should not be attempted if cerebrospinal fluid is draining from the nose and external auditory canal, as it would obviously be superfluous.

However, in properly selected cases spinal drainage is often employed to advantage. It finds its greatest application (1) in the uncomplicated progressive type of cerebral edema manifested by headache, restlessness, vomiting, slow pulse, and deepening of unconsciousness and (2) in meningeal irritation characterized by muscular rigidity, delirium, and elevation of temperature.

Technic of Lumbar Puncture. The spinal theca is tapped in the lumbar region below

the termination of the spinal cord The necessary instruments include a lumbar puncture needle, 18-gauge to 20-gauge for adults and 22-gauge for children, a spinal manometer (fig 215), and a syringe for anesthetization of the skin The method employed by Merritt and Fremont-Smith (158) is the most practical, and the technic is essentially as follows The patient is placed in the lateral recumbent position, as near to the edge of the bed or table as possible The thighs are flexed on the abdomen and the head is bent slightly forward on the chest in order that the spaces between the vertebrae may be separated The spinous processes of the lumbar vertebrae are palpated and the widest space selected for the introduction of the needle This is usually found between the third and fourth or fourth and fifth lumbar spines (fig 199) The skin of the back is sterilized and draped as for any surgical operation Over the site of puncture a wheal is raised with a 2 per cent procain solution A longer needle is then attached to the syringe, and the deeper tissues are infiltrated with 4 to 5 cc of the same solution

After the site has been anesthetized, a sharp 18-gauge needle with a 3-way stopcock is inserted exactly into the midline at right angles to the plane of the back, the hilt of the needle being held firmly with the right hand while the point is guided with the left The needle is forced directly forward until a slight decrease in resistance is felt, where-

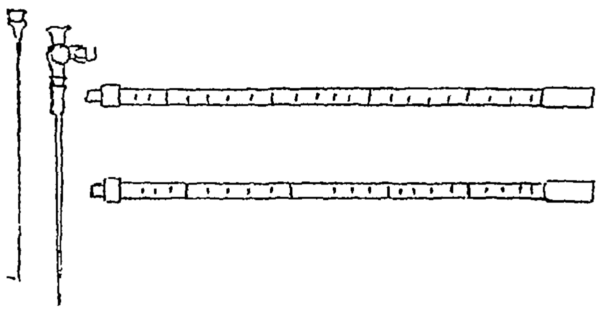


FIG 215 Fremont-Smith modification of Ayer lumbar puncture needle and manometer Three-way stopcock attached to needle permits of insertion of manometer without loss of fluid Manometer divided into sections of 200 mm each, to facilitate sterilization

upon the stilet is withdrawn to determine whether or not the needle is actually in the subarachnoid space If no fluid appears, it indicates that the needle has merely penetrated the spinous ligament It is therefore advanced a few millimeters, until a loss of resistance is again felt, indicating that the pachymeninx has probably been punctured If upon the second removal of the stilet no fluid appears, it is possible that the point may be obstructed, and the needle is shifted slightly to a new position If spinal fluid still fails to appear, the needle is completely withdrawn and reinserted in another direction As soon as fluid appears, the stopcock is turned to the neutral position, the manometer attached to its upper arm, the stopcock opened, and the pressure recorded

After this procedure the presence or absence of a free communication between the intracranial fluid and the fluid in the manometer is determined by means of Queckstedt's test, as follows The jugular veins are compressed by the application of digital pressure Normally, after 10 seconds there is a rapid rise in pressure to 150 to 300 mm of water, with a quick fall to approximately the original level as soon as the pressure on the veins is released If no such rise in spinal pressure ensues, it is suggestive of subarachnoid block

In the absence of obstruction the fluid is allowed to flow slowly from the needle,

the pressure being recorded after the removal of each 3 to 5 cc. If the reading is less than 200 mm. of water, the fluid should be drained to the normal pressure limits. But if it exceeds 200 mm., only enough of it should be withdrawn to cause the pressure to drop to half of its original level. For instance, when the cerebrospinal pressure has risen to 400 mm. of water, it should be reduced to 200 (183, 124, 190, 238, 239, 18) Munro (179) advises that when the pressure is above 160 mm. of water, enough cerebrospinal fluid should be removed to lower the pressure to 110 regardless of the amount required for this purpose The puncture may be repeated in 12 to 24 hours, should the symptoms warrant. When a considerable quantity of blood is found in the cerebrospinal fluid, the intervals between punctures should be reduced to 8 to 12 hours and the punctures repeated until all traces of blood disappear After removal of the needle the wound is covered with a drop of collodion

Cerebral Decompression The operation of cerebral decompression consists in the removal of a section of the skull. As in the case of dehydration and spinal drainage, there is much difference of opinion as to the therapeutic value of the procedure. Only the noteworthy points of this controversy need be mentioned. As previously stated, some surgeons believe that there is no middle course between watchful expectancy on the one hand and cerebral decompression on the other They are of the opinion that an early operative decompression will forestall the detrimental organic changes in the brain following prolonged intracranial pressure. They advise that a decompression be performed as soon as there is evidence that the pressure is increasing and that compensation will not take place without surgical intervention Others condemn the operation on the assumption that edema of a degree sufficient to endanger life cannot be materially reduced by the removal of a small button of bone from the skull, and that such an expedient merely inflicts more injury But the majority take a middle course performing an operative decompression only after conservative measures have proved unsuccessful. At the first signs of intracranial pressure, provided the symptoms do not point to intracranial hemorrhage, they attempt to afford relief by recourse to dehydration or spinal drainage. If these measures fail to cause stabilization and if the symptoms of compression persist or increase, they resort to cerebral decompression The difficulty here lies in determining the exact time at which decompression will be most effective, a decision requiring a thorough study of the clinical features and nice surgical judgment.

Specifically, decompression is indicated under the following circumstances (1) when concussion merges into compression, as in the case of hemorrhage from the middle meningeal artery, (2) when symptoms of cerebral irritation persist despite attempts for their relief by palliative measures, (3) when the patient has at first responded to non-surgical treatment but later develops compressive symptoms, and (4) when compression is associated with compound injury of the scalp severe comminution of the bone, or laceration of the brain and meninges. As soon as the indication is defined, decompression should not be delayed, since brain tissue is quickly destroyed by ischemia, and once the compression passes beyond the stage of compensation, operation is of no avail.

Instruments The necessary instruments for decompression include a suction apparatus, a lumbar puncture needle and manometer, straight and angled knives, Adson's scalp clips and forceps hemostats, periosteal elevators (straight, curved, sharp, and

dull), a Hudson's brace with three sizes of burrs, cranial rongeurs (straight and curved), a gigli saw, dural hooks (sharp and blunt), dural forceps, ganglion scissors, Cushing's clip forceps and holders, a silver probe, a grooved director, cotton packs and cotton balls, Penrose drains, small curved needles, and #1 silk (fig 216)

Anesthesia A local infiltration of the temporal scalp with 1 per cent solution of procain and adrenalin is all that is necessary when the patient is unconscious, as is usually the case, since the bone and pachymeninx are relatively insensitive The edema accompanying the infiltration is of special advantage in that it facilitates the

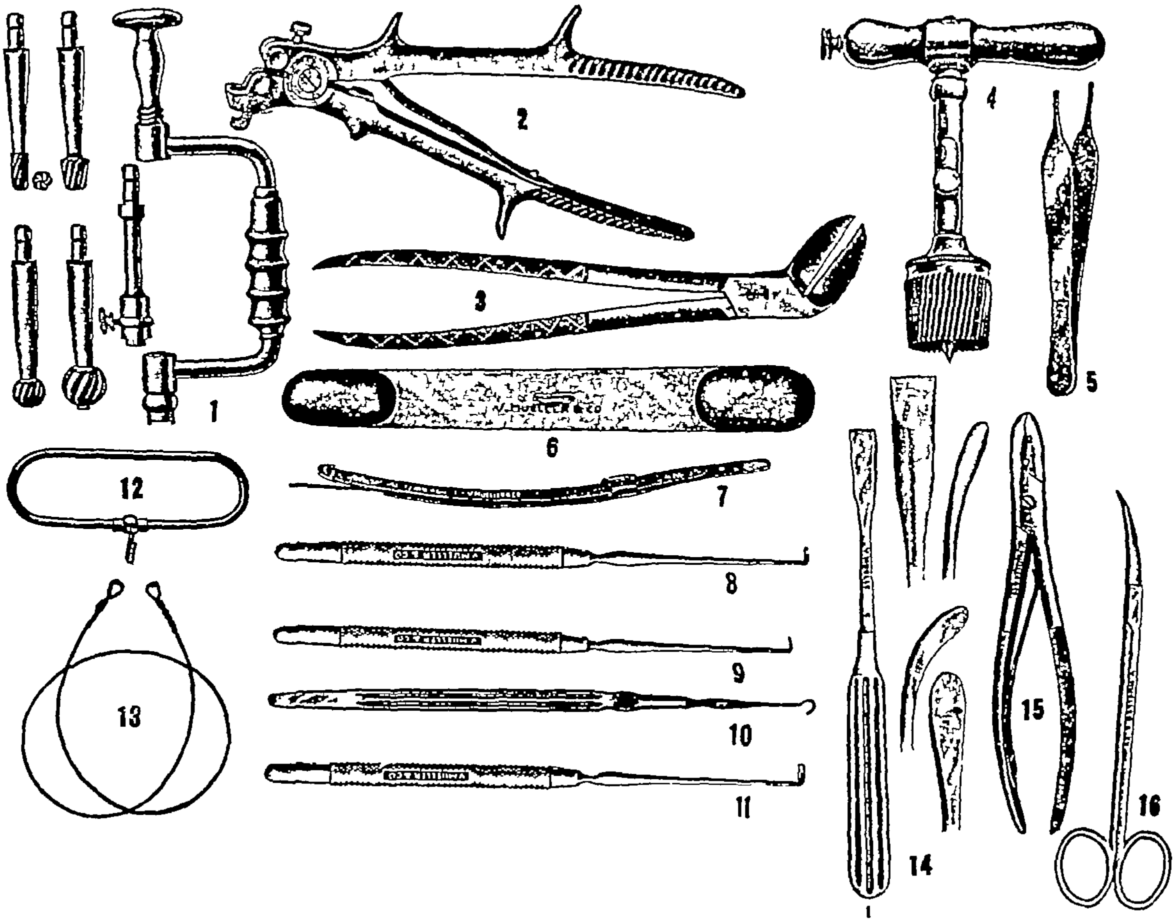


Fig 216 Instruments for craniotomy *1*, brace with variously sized burrs (Hudson), *2*, cranial forceps (Hudson), *3*, sideways bone-cutting forceps (Mayo), *4*, trephine, *5*, tissue-forceps (Adson), *6*, brain spatula (Cushing), *7*, conductor for gigli saw, *8*, blunt dissecting-hook (Adson), *9–10*, dural hooks, *11*, right-angled knife (Adson), *12*, handle for gigli saw, *13*, gigle saw, *14*, periosteal and dural separators (Adson), *15*, cranial rongeur (Adson); *16*, ganglion scissors

securing of the blood vessels The needle is inserted at a point 2 5 cm in front of the ear, at the level of the upper border of the zygoma, and the infiltration is carried upward into the scalp for a distance of 8 to 10 cm For patients in a semiconscious state the local agent is supplemented by avertin When a general anesthetic must be resorted to, the most satisfactory agent is cyclopropane administered endotracheally Chloroform and ether are both contraindicated, since the former is a depressant, while the latter, by raising the blood pressure, may cause a recurrence of a previously arrested hemorrhage in the cranial cavity Throughout the operation it is essential that the blood pressure, respiration, pulse, and temperature be recorded at frequent intervals

Technic The patient's head is shaved and the scalp cleansed in the usual manner The head, supported on a sand bag at a convenient height, is rotated and draped so as to expose the site for decompression.

The decompression should, when possible, be done in the subdivision in which the brain lesion is situated, irrespective of the location of the fracture. This can frequently be determined by the neurologic manifestations (p 534) If the pupils are unequal, the operation should be performed on the side of dilatation, when there are no pupillary changes, it is done on the side opposite the muscular paresis or rigidity In the absence of indicatory signs, the decompression is effected in the temporal region on the left side. Dandy (52) operates through an incision along a line which extends across the vertex between the tragi. This is an excellent incision as it can be curved backward or forward if necessary, and it provides a sound muscle over the remaining cranial defect. Another convenient incision is that suggested by Cushing (46) which

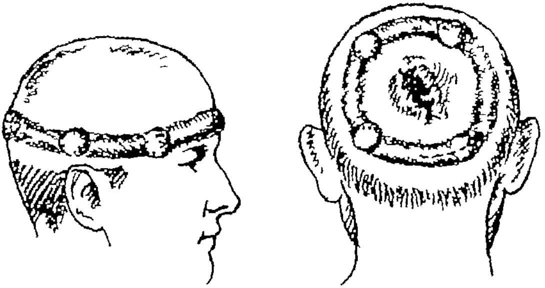


FIG 217 Anesthetization of scalp by circumferential infiltration.

begins 6 cm. above the ear and extends diagonally downward and forward to the zygoma, ending at a point about 1 cm. in front of the ear

Hemorrhage from the scalp is apt to be profuse, and a variety of methods are used for its control. The use of a tube wrapped around the head has been suggested (fig 220a), but practically, such a tourniquet is seldom effective, as it has a tendency to slip and obstruct the field of operation. Heidenhain's sutures (fig 220b) and Makkas' clamps are equally ineffective. A more satisfactory method of securing hemostasis is by the use of Adson s clips (fig 220c) or by picking up the galea beneath the severed vessels with several pointed, curved forceps placed 1 cm. apart, and turning the forceps over the edge of the scalp thus throwing the aponeurosis forward over the bleeding points (fig 220b) The weight of the instruments will be sufficient to compress the vessels and check the hemorrhage. The handles of the many forceps can be conveniently managed if several of them are included in a rubber band.

The fascia overlying the temporal muscle is divided in the direction of its fibers, after which the muscle is split in the same manner and separated by means of a stout elevator from the underlying temporal bone. With a trephine the skull is then perfor

ated at a point 5 cm. above the level of the zygoma (fig 214) When the instrument is felt to have almost passed through the bone, it is removed, and the remaining part of the inner plate pried out with a Horsley elevator During the drilling the area must be continuously irrigated as a precaution against tissue damage from overheating With a dural elevator the pachymeninx is next separated from the inner surface of the skull in the region of the drill opening If intracranial pressure is found to be considerable, the perforation in the skull should be enlarged for a distance of 5 to 6 cm by the use of a nibbling or de Vilbiss forceps, otherwise, there is danger of herniation and disintegration of the brain tissue The enlargment is best made in a downward direction, so that after operation the thickest part of the muscle will afford protection to the remaining aperture in the skull Removal of the bone may occasion serious bleeding either from the bone itself or its emissary veins, or from the meningeal vessels Such hemorrhage, if originating in the bone, can be controlled with *Horsley's wax

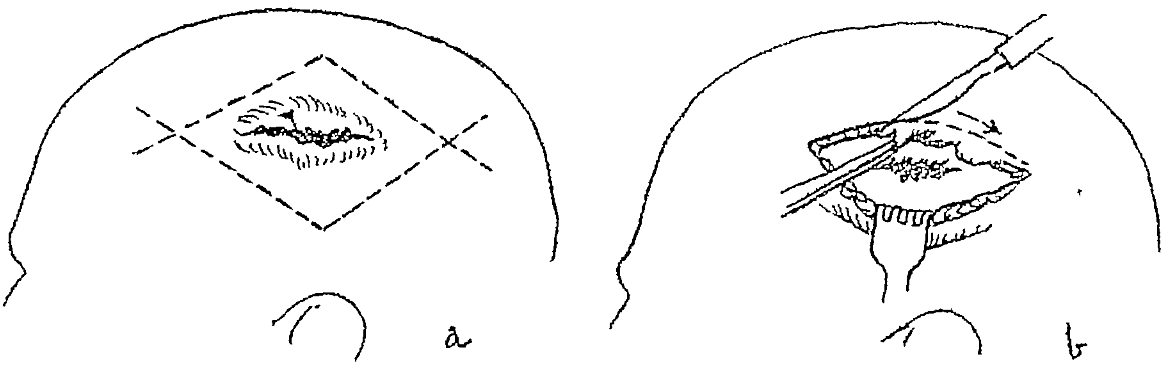


FIG 218 Débridement of scalp wound a, dotted line indicates limits of local anesthesia b, lacerated margins débrided for distance of 1 or 2 cm

pressed against the bleeding points (fig 223), if from the meningeal vessels, by recourse to ligation or electrocautery

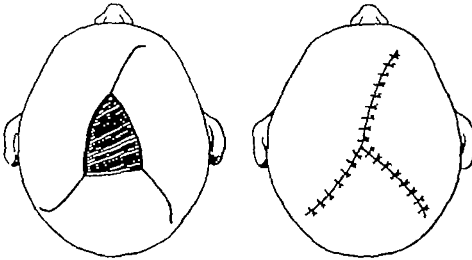
*(Yellow wax	7 parts
Carbolic acid	1 part
Olive oil	2 parts

Melt the wax with the oil, strain through muslin, add the carbolic acid and stir until dissolved Keep in a sterilized bottle covered with mercuric chlorid solution)

The pachymeninx is now carefully examined If inspection shows any alteration in color, increased or decreased vascularity, and an absence of pulsations, and if palpation reveals an increased resistance or fluctuation, a subdural hemorrhage may be assumed Under such circumstances the pachymeninx is opened by means of a crucial incision over the middle of the decompressed area, through an avascular space if possible Should there be vessels in the field, provision must be made to control bleeding When large and not too numerous, they can be underrun with a needle and ligated on each side of the proposed line of incision When small and not situated over the motor area or in the vicinity of a dural sinus, they may be coagulated with a fine electrode To avoid injury to the cortex, the pachymeninx is picked up with a dural hook, and a nick is made in it sufficiently large to permit of the introduction of a grooved director With the aid of this instrument and a pair of straight scissors the incision is then en-

larged in various directions, until it corresponds in size to that of the bone opening As soon as the unyielding pachymeninx is cut, the brain will bulge outward through the opening and immediate relief from the compression symptoms will follow The dural flaps are replaced but not sutured the edges of the bone are rounded off, continuity is restored to the split muscle by a few catgut sutures, the temporal fascia is closed, and the scalp united without recourse to drainage. Should this procedure fail to relieve the symptoms, the compressing force may be assumed to be in another compartment. In such a contingency the patient's head is turned, and a similar operation is performed on the opposite side.

For several days following operation the patient must be kept on a low diet, the fluid intake restricted, irritability controlled by the administration of sedatives, such as potassium bromid, and insomnia combated with luminal in 0 12-gram (2-grain) doses.



a *b*

Fig 219 Closure of scalp wound by triangular excision and extension of angles in form of tripod. *a*, defect with angles extended. *b* three flaps thus formed mobilized and approximated in form of Y (Cushing)

LOCAL TREATMENT

Scalp Wounds

Even slight wounds of the scalp demand serious consideration, since the blood and lymphatic supply of this region provide avenues by which infection may readily be carried into the skull, especially in the presence of an associated fracture Hemorrhage is apt to be profuse, owing to the intimate connection between the fascia and the walls of the blood vessels which prevents their retraction. In wounds of a limited nature hemostasis can be secured by means of pressure with a sterile tampon or a head-bandage. Recourse to clamping and ligation of the individual bleeding points is unsatisfactory In extensive scalp wounds bleeding is best controlled if the cut margins of the epicranial aponeurosis beneath the bleeding vessels are seized with hemostats and the handles of the instruments thrown away from the wound (fig 220) The aponeurosis is thus drawn over the divided vessels and the hemorrhage automatically checked.

When hemostasis has been secured, the subsequent management of the scalp wound will depend on the general state of the patient. In the presence of concussion or shock the wound is covered with a sterile dressing, and no attempt is made to cleanse, débride,

or close it until the patient is able to tolerate such a procedure A history or evidence of soil contamination calls for the administration of 1500 units of antitetanic serum, and should the parts be badly contused, 4000 units of polyvalent antigas gangrene serum are introduced intramuscularly (p 268)

As soon as the patient's condition permits, his head is shaved well beyond the injured area, cleansed with soap and water, care being taken that no dirt is washed into the wound, and swabbed with benzene or ether to remove the grease The wound itself is then swabbed with ether and the part anesthetized by circumferential infiltration

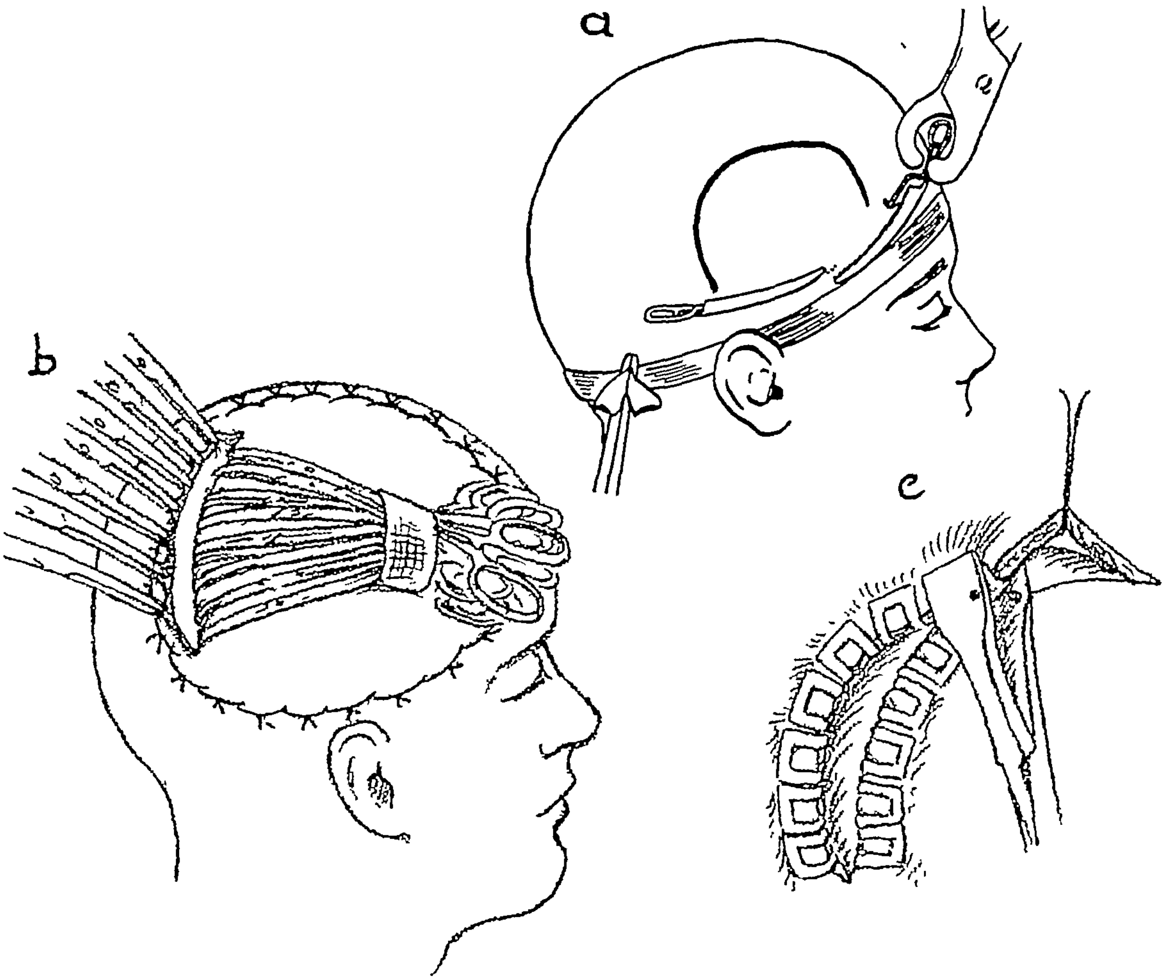


FIG 220 Various methods of controlling hemorrhage from scalp *a*, rubber tourniquet wrapped around head, supplemented by use of Makkas' clamps *b*, Heidenhain's suture, supplemented by drawing aponeurosis over bleeding vessels *c*, Adson's scalp clips

with procain epinephrin (fig 217) The edges of the wound are widely separated, and a search is made for foreign bodies, such as blood-clots and macerated muscle, road dirt, hair, shreds of cloth and other débris, which, if found, are removed with a fine forceps The skull is inspected and palpated with a sterile-gloved finger for evidence of fractures (p 552) Under no circumstances should the wound be probed, because of the danger of introducing infection Should a fracture be discovered, irrigation of the wound is contraindicated, as such a procedure may drive infection into the cranial cavity. Loose fragments of bone should be removed, but those still attached to the

periosteum are best left in place. Soiled and crushed margins may be pinched off with a rongeur Since scalp wounds are potentially infected, the lacerated margins should be trimmed, so that clean and healthy surfaces can be approximated, the extent of the débridement depending upon the degree of contusion and the interval between the receipt of injury and its management (p 271)

If the wound is clean and local treatment can be administered within 6 to 8 hours after injury the lacerated margins are débrided for a distance of 1 or 2 cm. (fig 218), and the wound is sutured with fine silkworm-gut on a curved cutting needle passed through the full thickness of the scalp The stitches should be placed far enough apart to permit of the escape of the secretions, otherwise, these discharges may pass into the loose subaponeurotic layer and give rise to hematomata or abscesses. If the epicranius muscle has been severed, the scalp wound after closure should be immobilized by means of adhesive strips, so that the tendency of the wound margins to separate through contraction of the divided muscle may be counteracted. When a considerable amount of scalp tissue has been destroyed and the wound margins cannot be coapted without tension incisions made in the adjacent healthy scalp parallel to the long axis of the wound may furnish the necessary relaxation to obtain closure. The secondary defects left by these incisions may either be skin-grafted or left to granulate. Another alternative is the excision of the wound in the form of a tripod, and the approximation of the three flaps thus formed in the form of the letter Y (fig 219) Closure may also be effected by the use of sliding flaps. Such a procedure is especially applicable in this locality, since the final scar will be concealed in the hair In case there is not sufficient tissue to provide such a flap, the defect may be covered either with a split skin graft or with a flap taken from another part of the body (Chapter II)

If treatment is delayed beyond 8 hours following the injury, or if the wound is of such a character that infection is anticipated, adequate drainage must be provided (p 275) Rubber bands are introduced between the sutures, or the sutures may be placed but left untied, and the wound packed with vaselin gauze. The part is covered with a moist dressing which is renewed at frequent intervals, so that the progress of healing may be followed At the end of the third day, provided there is no evidence of infection, the drain is removed and the wound closed.

Should the scalp wound become infected or be already infected when first seen, any previously placed sutures are removed and drainage instituted, otherwise, there is the danger that the infection may spread to the subaponeurotic layer and be carried into the cranial cavity by way of the emissary veins. Moist compresses are then applied until the infection becomes localized, at which time the area is incised and treated in the same way as an abscess in any other part of the body

Following scalp injuries hematomata frequently form beneath the skin, the aponeurosis, or the pericranium As a rule these blood collections are absorbed spontaneously and require no treatment aside from the application of a firm pressure bandage. Should they persist, however, they must be removed. It is often possible to aspirate the blood and serum through a large trocar should this expedient fail, a small incision is made in the overlying skin and the hematoma evacuated When the clot has been removed, a pressure dressing is applied and held in place by means of a firm bandage. A satisfactory method of obtaining pressure is by the incorporation in the dressing of a sterile marine sponge wrung out of normal salt solution

Avulsion of Scalp

Avulsion of the scalp is a fairly common industrial accident, large portions of the scalp being torn from the head by the tangential pull of an unguarded machine The separation usually occurs in the subaponeurotic layer at the point where the scalp is thinnest, common sites being just above the ears and along the supra-orbital ridges As a rule the pericranium remains attached to the bone, but if the covering is not restored, this layer soon disappears, leaving the bone to undergo a slow necrosis

Portions of scalp tissue still attached by a pedicle should be shaved and cleansed, the bruised edges débrided, and the flap sutured back into place Because of the excellent blood supply in this region the avulsed portion is likely to "take," even though the pedicle is slender But when a section of the scalp has been entirely separated, replacement of its full thickness offers little chance of viability, since the pericranium forms a poor nourishing base for such a graft However, when the detached portion is clean, a split-skin graft may be cut from it and utilized to cover the denuded area (p 140) Even should such a graft fail, nothing is lost, since in any event it forms a good dressing

Skull Fractures

The customary anatomic classification of skull fractures into linear, stellate, fissured, etc , is of little assistance in the management of skull injuries, since it takes no account of the effect of the trauma upon the cranial contents Skull fractures in themselves have little surgical significance They are important only in so far as they indicate the degree of violence inflicted and thus furnish an index to the possible damage to the brain. If unaccompanied by intracranial injury, they present no particular problem and require no operative intervention, as they will unite in the same manner as fractures elsewhere Surgical interference is demanded only when they are depressed or compound, or are associated with an extensive loss of tissue

The management of *depressed fractures* will depend upon (1) the presence or absence of associated brain injury, and (2) the location and size of the fracture When symptoms of local or general intracranial pressure are present, the necessity for operative interference cannot be questioned, and all surgeons agree that the depressed fragment should be elevated But in depressed fractures which present no cerebral symptoms opinion is divided concerning the proper management Some favor a conservative course, while others advise operation in all cases on the grounds that in no other way can the presence of hematomata, splintering of the inner plate, or lacerations of the pachymeninx with their posttraumatic neurologic sequelae be definitely excluded Probably the best plan, in the absence of brain symptoms, is to take an intermediate stand and operate only in selected cases, basing the decision upon the location, size, and nature of the fracture For instance, a shallow fracture over a "silent area" of the brain is probably best treated conservatively, but a depressed fracture with the bone turned edgewise over the motor area, even in the absence of cerebral symptoms, had best be elevated

All *compound fractures* of the skull carry the potential danger of infection, and, if depressed, they suggest the additional possibility of immediate damage to the pachymeninx and brain Therefore, operative intervention is necessary, not only for the

prevention of infection, but also for the relief of any intracranial pressure that may be present.

As has been said before, the brain injury and the general condition of the patient should always receive first consideration, regardless of the type of fracture. Attention to the fracture itself is postponed until he has recovered from shock and can tolerate the necessary manipulation The only exception is when the fracture is associated with hemorrhage from the middle meningeal artery in which case the control of bleeding takes precedence over all other considerations.

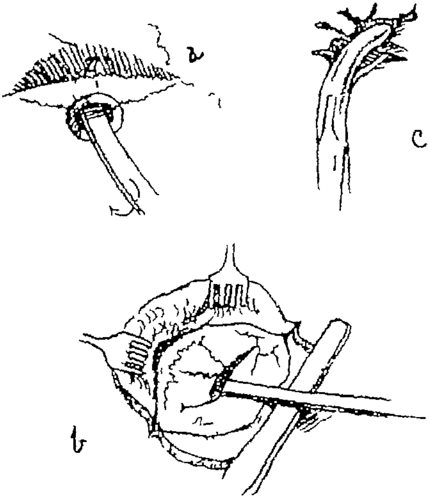


FIG. 221 Various methods of elevating bone in depressed fracture of skull. *a* trephine opening made in healthy bone at margin of fracture. Through this opening, depressed fragment levered into position. *b* bone elevated through fracture line *c*, depressed fragments removed with rongeur forceps. For details, see text.

While fractures of the vault and base do not differ from one another and usually occur in combination, yet, because of the varying character of the brain structures underlying these fractures, they will be discussed separately

Management of Vault Fractures. The fractured area is exposed by turning down a scalp flap (p 586), unless the soft tissues are lacerated, in which case the scalp wound offers a convenient approach The manner of dealing with the bone itself will depend upon the conditions found

(1) *Reduction* In the case of *simple depressed fractures* of the vault the damaged bone area, if small, is removed with a trephine, and the interior of the skull is inves-

tigated If the pachymeninx and brain are found to be uninjured and there is no evidence or danger of infection, the disk of bone is replaced, otherwise, the segment is discarded The small gap remaining will in time be filled in The tradition handed down by Pott (204) that the cranial bones are incapable of regeneration has been challenged by Fuerstenberg (92), Cushing (46), and others (17), who have found that while the process is not as active as in other bones, a certain amount of spontaneous bone repair does take place Should unaided closure fail to occur, the defect may be reconstructed later by a plastic operation (p 581)

If the depression is large, a trephine opening is made through healthy bone at the margin of the fracture Through this perforation a strong, dull elevator is inserted between the bone and the pachymeninx, and the depressed fragments are levered into position (fig 221) Should hemorrhage ensue as the bone is being elevated, it is indicative of a laceration of the middle meningeal artery, the management of which has already been discussed (p 540) In case elevation of the fragment is found to be impracticable, the damaged bone is removed (fig 222) Five or 6 perforations are made with a perforating burr mounted on a Hudson's brace and are enlarged by the substitution of a rongeuring burr for the latter instrument Through these holes a dural separator is introduced, and the pachymeninx is separated from the inner surface of the bone With the aid of a conductor, a gigli saw is drawn beneath the bone connecting two holes The handles are applied and the instrument worked back and forth until the bone is cut through This manoeuver is repeated until the bone segment outlined by the burr holes is entirely freed

Compound fractures of the vault, if small, are best excised with a trephine and nibbling forceps, but if large and depressed, the fragments are first raised with an elevator introduced through the fracture line (fig 221), and the contaminated margins are then excised with a bone forceps, the extent of débridement depending upon the condition of the wound When the pachymeninx is undamaged and clean, it will be sufficient to excise the margins only, but if the membrane has been torn and the brain contaminated, a wider removal of bone is necessary

When the narrowness of the fracture line does not permit of the introduction of an elevator, a trephine opening is made for the insertion of the instrument, the appropriate site being determined by a roentgenographic examination The perforation must be made in healthy bone adjacent to the depression, must furnish sufficient support for the pressure necessary to carry the trephine through the bone, and at the same time must not overlie any of the dural sinuses or the middle meningeal artery The center pin, projecting 2 to 3 mm , is driven into the selected site, the rim of the trephine projecting over the fractured area (fig 214). The trephine is worked from side to side until the teeth have made a definite groove, after which the pin is removed, the trephine cleaned and reapplied, and the groove deepened Since the skull is not of equal thickness throughout (p 520), the depth of the groove must be tested with a probe from time to time, in order to avoid injury to the brain Perforation of the outer plate will be evidenced by a lessening resistance and more abundant hemorrhage When the groove is of sufficient depth to show a few points of perforation, the trephine is removed and the disk of bone pried out with an elevator, the sound adjacent structure being used as a fulcrum Through this opening the depressed bone is elevated (183) (fig 221)

When the fracture lies over a cranial sinus, a biting forceps is substituted for the trephine and the bone fragments removed bit by bit, to guard against laceration of

the sinus. Should such an accident occur, hemorrhage is controlled either by the application of a piece of muscle over the bleeding area or by encircling the sinus with a silk ligature. The use of hemostats for this purpose is contraindicated, since they are likely to cause further trauma to the part. Packing is also to be avoided, as it carries the potential danger of infection. *Small or soiled bone splinters are discarded,* large pieces are cleaned and saved to be used later to close the defect.

(2) *Management of Intracranial Structures* If the pachymeninx has not been torn and appears normal, great care must be taken that it be kept closed, to avoid the risk of brain infection. But if the membrane is discolored and bulging, or subdural hemor

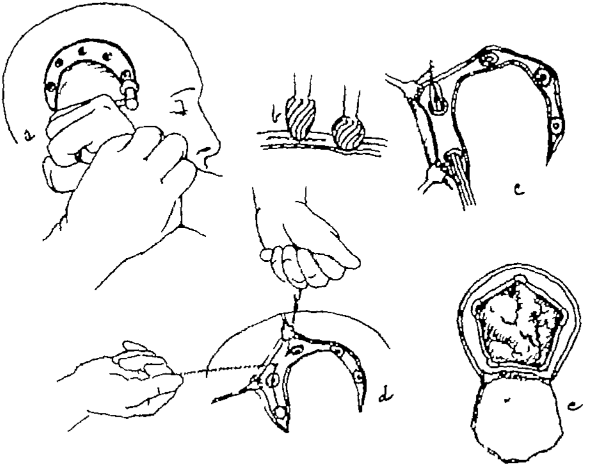


FIG. 222. Resection of skull. *a*, perforations made with burr mounted on Hudson brace and enlarged with rongeuring burr *b* sectional view showing effect of perforating and rongeuring burr Perforating burr used to penetrate bone down to inner plate rongeuring burr to enlarge opening. *c* dural separator introduced, and gigli saw drawn beneath bone. *d* handles applied, and bone between holes *cut through.* *e* *osteoplastic flap turned back.*

rhage is suspected, it should be incised for purposes of investigation The incision should be made in clean pachymeninx, even though it may become necessary to remove additional bone in order to do so If the membrane is lacerated, the margins are trimmed and the wound enlarged, so as to adequately expose the underlying cortex. Loose fragments of brain tissue, extravasated blood, splinters of bone, and foreign bodies, if present, are then carefully removed by irrigation with normal salt solution, by gentle suction, or by means of a forceps (fig 224) All bruised cerebral tissue is excised. Hemorrhage, if venous—as is usually the case—may be permitted to stop spontaneously, or it may be controlled by the application of small bits of muscle to the

open ends of the cut veins. Arterial bleeding is controlled by ligating the severed vessel with fine silk or silver clips

(3) *Closure* At the completion of the operation the pachymeninx is closed, provided there is no likelihood of a subsequent increase in intracranial pressure. The margins are coapted as tightly as possible by means of interrupted sutures of fine silk If tensionless closure cannot be effected, relaxation incisions are made in healthy dura on either side of and parallel to the wound In this manner the cortex will be better protected and the danger of adhesions minimized Should the loss of pachymeninx be too extensive to permit of approximation of the wound margins, the defect may be patched with a piece of temporal fascia or galea Except in the presence of gross contamination, drainage should be avoided, since the advantages of a drain are offset

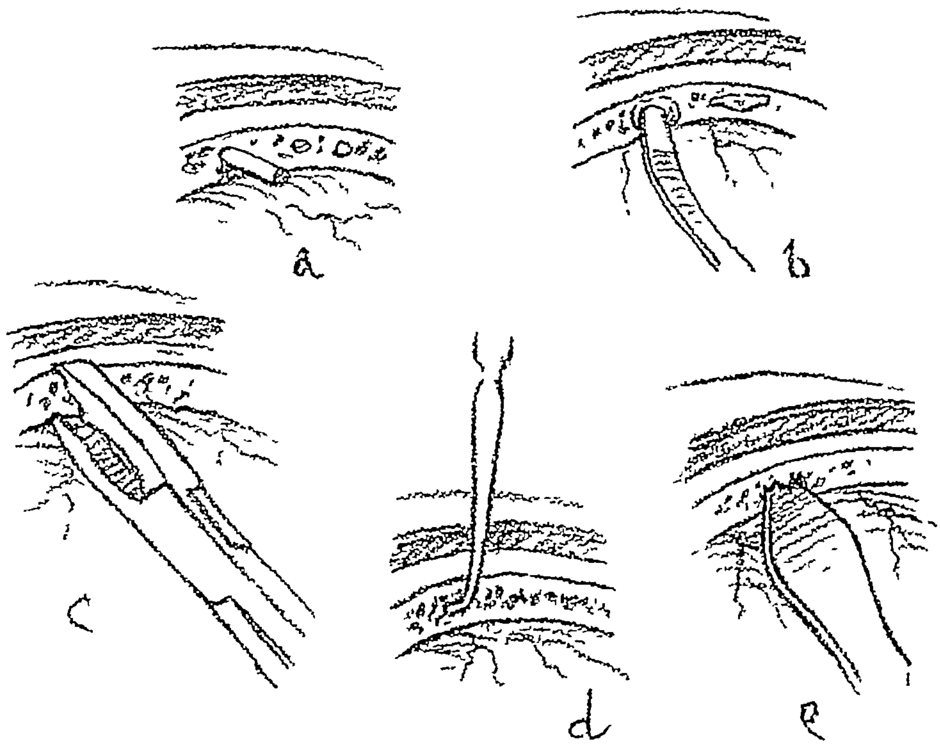


FIG 223 Methods employed to check hemorrhage from diploic vessels *a*, by plugging bone with wooden or ivory pegs *b*, by application of Horsley's wax or bits of muscle *c*, by crushing bone *d*, by Krause's hook *e*, by pressure with elevator (Kirschner's Surgery)

by the dangers of brain hernia, meningitis, and abscess formation. The dura having been closed, the previously removed bone fragments, if clean, are replaced to help obliterate the skull defect The scalp wound is closed in two layers, fine silk being used for the purpose Suturing is begun at the periphery and carried toward the center of the wound, tension being avoided by undermining. No drainage of the scalp wound is necessary, unless there is a probability of infection, in which case the primary wound is entirely closed and a rubber drain inserted through a separate stab-incision and stitched to the scalp Finally, the wound is covered with a dry sterile dressing held in place by means of a bandage

When the fracture is seen late, or if infection has already taken place, the dural and scalp wounds are left open and packed lightly with vaselin gauze In such cases healing is almost always complicated by the formation of a cerebral fungus which,

according to Dowman (64), is best treated in the following manner The fungus is cleansed by syringing the surface with normal salt solution. The surrounding scalp is scrubbed and shaved with a sterile razor, cleansed with alcohol, and dried with a sterile sponge. A layer of sterilized gutta-percha tissue is placed around the fungus, and over this is laid a sterile cotton "doughnut" of sufficient size to surround the fungus and protect it from all pressure. Numerous squares of gauze are then superimposed on the "doughnut," the whole being well bandaged to prevent slipping

Management of Basal Fractures. Basal fractures are usually associated with more cerebral damage than are those of the vault, and therefore offer a more serious prognosis, the mortality being estimated at 60 per cent. Owing to the closer attachment of the pachymeninx to the bone in this region, there is more likelihood that the membrane will be torn, and due to the proximity of the ears, nose, mouth, and sinuses, there is a greater danger of infection.

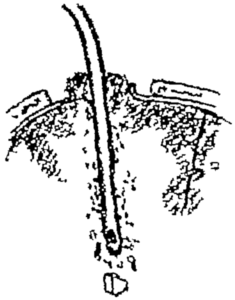


FIG. 224 Cushing's method of irrigating brain wound with normal salt solution through catheter

Fractures of the base are usually transverse or oblique, and take an irregular course, extending from one anterior cranial fossa to the opposite anterior fossa, or to a middle or a posterior fossa. The parts weakened by the presence of foramina will give way, while the lines of fracture will run around the stronger more resistant bony buttresses. The usual sites, according to Rawling (212), are those shown in Figure 225 Because of the inaccessibility of the skull base, the uncertainty as to the exact location and extent of the fracture, and the difficulty of determining the presence or absence of dural laceration, the treatment unlike that of fractures of the vault, must necessarily be conservative and limited to the prevention of infection.

Whether or not infection takes place will depend upon the previous condition of the paranasal sinuses and the presence or absence of lacerations in the pachymeninx. Aseptic management will usually prevent it provided the sinuses are free from infection at the time of injury and the pachymeninx has remained intact. If cerebrospinal fluid is draining through an orifice, nothing should be done to hinder its escape, it is gently mopped away with pledgets of sterile cotton Douching or plugging of the nose is contraindicated, since a douche may drive infectious material into the skull and a pack

may dam back unsterile secretions The patient is cautioned against blowing the nose, lest there ensue emphysema of the cranial cavity The ear, if discharging, should be covered with a sterile dressing and should not be syringed or plugged. Hexamin is administered by mouth three times daily in 0 6-gram (10-grain) doses for its supposed bactericidal effect on the cerebrospinal fluid

If infection supervenes, it usually manifests itself after the third day following injury and is treated along general lines (p 274).

Gunshot Wounds of the Cranium. The mechanism in the production of gunshot fractures of the head is well described by Babcock (6):

"1 At short range the calvarium and scalp are blown to pieces by the entrance of a bullet at great speed into the semifluid and practically incompressible brain which,

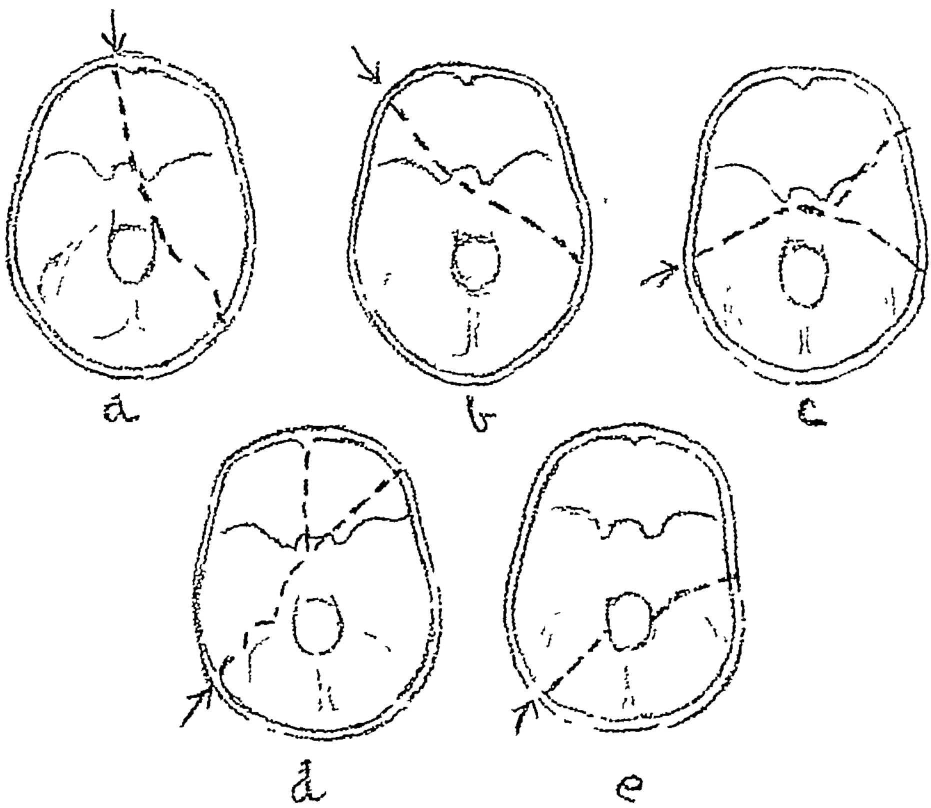


FIG 225 Usual sites of basal fractures Arrows indicate direction of force *a*, site of fracture caused by median frontal force *b*, by lateral frontal force *c*, by lateral force *d*, by force applied to mastoid region *e*, to lateral occipital region (Rawling)

not having sufficient time to be displaced, transmits the hydrodynamic force in all directions with a bursting effect upon the rigid walls of the skull The brain may be carried several meters from the skull (exenteratio cranii) 2 At 50 meters the scalp is perforated, but the skull is comminuted In warfare, these explosive effects have led to the false belief that dum-dum or explosive bullets were being used 3 At 100 meters the skull shows areas of bending and bursting fracture about the points of entrance and exit, the area of entrance being small, and that of exit being up to 20 cm in diameter 4 At 800 to 1200 meters only radial fissures are found about the perforations 5 At 1800 to 2000 meters there are drill effects or clean-cut, punched-out holes of entrance and exit 6. At 2000 to 2700 meters the average skull is not perforated, but radial, depressed, or comminuted fractures may be produced (von-Berg-

mann) Variations occur dependent upon the size, weight, and velocity of the bullet, and the thickness and strength of the skull. 'Soft nose' bullets, the apex consisting of soft lead which mushrooms on impact, and 'dum-dum' bullets, which have hollow soft points, or the point of which contains a hollow chamber which bursts on impact, produce widespread comminution Tangent wounds (if the bullet strikes at a tangent) cause a grooved or circular fracture, often associated with bending If linear or circular fracture occurs, the bullet may split, straddle the bone, or break into fragments. Pistol or revolver wounds, except those from a high-velocity Automatic, even at short range, cause few or no radial fractures, and the bullet rarely traverses a thick skull. One or two concentric fractures may be produced. The lesions, therefore, resemble those produced by spent bullets of initial high velocity Similar wounds are also caused by shrapnel. The fragments of high-explosive shell may produce large defects in the skull and brain, the shell fragments, bone, and other foreign bodies being carried into the cerebral substance to be encapsulated and retained, to gravitate with secondary symptoms, or to produce spreading infection. In a few instances a large foreign body, as the minie ball, weighing 30 Gm. which was used in the Civil war, has been retained in the brain for many years without symptoms."

Gunshot wounds of the head are treated in the same manner as head injuries due to other causes. In the absence of brain symptoms, the treatment is expectant, but if there are signs of cerebral damage, operation is indicated, even in the absence of skull fracture.

If the shot has produced a comminuted fracture and splinters have penetrated the brain, they are carefully removed with a fine forceps and all contused brain tissue excised If it is possible to institute treatment within the first 8 hours following injury, the overlying wound is closed without recourse to drainage. But when treatment must be delayed beyond this period, sutures are placed but not tied, packing is introduced, and the wound closed after the third day, provided there are no signs of infection

In the case of a superficial penetrating gunshot wound unassociated with comminution, the surrounding contaminated bone is débrided and all splinters and foreign bodies removed from the brain tissue If the bullet is easily accessible, it is lifted out, but if deeply embedded, it is not disturbed, unless there is evidence of infection, in which event its exact location should first be determined by an x ray examination. Cushing (42) suggests that the tract made by the missile be gently irrigated with sterile normal salt solution, introduced through a catheter (fig 224)

Perforating gunshot wounds are treated expectantly, since the bone in such cases is rarely shattered and the length of the canal precludes exposure and débridement.

Prognosis of Head Injuries

The mortality resulting from head injuries depends principally upon the presence, location, and severity of the intracranial damage, and, to a lesser degree upon the treatment instituted. Babcock (6) estimates that simple fractures of the skull without cerebral complications show a death rate of 5 per cent, compound fractures without cerebral lesions 10 per cent compound fractures with injury to the meninges but without cerebral damage, 20 per cent, but with cerebral trauma, 40 per cent. According to Dandy (49, 52), if treatment of all patients with severe injuries of the head were left to nature, about 70 per cent would recover, of the 30 per cent remaining, 20

per cent would immediately have to be regarded as beyond help, owing to massive brain injury, and the only hope for the remaining 10 per cent would lie in the institution of appropriate active measures of relief Out of 1000 head injuries treated in Bellevue Hospital in New York by Wortis and Kennedy (260), 37 8 per cent ended fatally Mock, Morrow, and Shannon (164), in a report on 3,278 cases, showed a mortality ranging from 26 to 40 6 per cent, while Fay (81) among 700 cases found an average mortality of 14 5 per cent

Neurologic sequelae developing weeks to months after the receipt of severe head injuries are common In a study of 100 cases of skull fracture observed over a period of from 5 to 13 years, Earley (69) found that 37 per cent of the patients suffered from residual symptoms, such as headache, vertigo, deficient memory, traumatic psychoses, personality changes, convulsions, diplopia, impaired hearing, facial palsy, and hemiplegia, and that 6 per cent were incapacitated by these complications

Posttraumatic sequelae constitute the most puzzling and difficult phase in the treatment of head injuries, but their management is a problem for the neurosurgeon Suffice it to say here that the more accurate the diagnosis of the initial injury, and the better the judgment exercised in the choice of treatment and the time of its application, the less likelihood there will be of these complications For instance, if intracranial pressure is allowed to persist for a considerable time, the resultant anoxemia may cause irreparable damage to the nerve cells, which in turn may give rise to posttraumatic sequelae There are cases, however, in which certain residual phenomena cannot be avoided Contusion of the temporal lobe, for example, may leave the patient with an auditory or visual aphasia, or injury to the motor area may be followed by traumatic epilepsy If the contusion is widespread, it may interfere with nerve pathways and result in one or more of the following symptoms, which, because they cannot be explained on a mechanical basis of increased brain pressure, adhesion, or irritation, are considered functional and referred to as "posttraumatic neuroses," "psychasthenia," or "hysteroneurasthenia" Such symptoms include headache, apathy, vertigo, irritability, nervous and mental disorders, weakness of memory and judgment, emotional instability, and personality changes

OSTEOMYELITIS OF SKULL

Historical records prove that surgeons of antiquity recognized the nature of osteomyelitis of the skull, and that Hippocrates made it the subject of a thesis But little attention was focused on the condition until 1760, when Pott (206) described a traumatic localized necrosis of the skull accompanied by suppuration of the overlying scalp—a lesion which even today is designated as "Potts's puffy tumor" In 1859 Chassaignac (33) and in 1889 Lannelongue and Von Bergmann (139) drew attention to the association of extradural and subdural abscesses with inflammations of the skull But only in the past few years, due to the efforts of McKenzie (153), Munro (181), Bulson (31), Wilensky (253), Fuerstenberg (92, 93), Mosher (173, 174), and others, has the diagnosis been facilitated and the principle of treatment laid down in definite terms

Etiology

Osteomyelitis of the skull occurs most frequently in women between the ages of 15 and 30 (259), probably because of the well-marked diploic development at this period

of life. As a rule, the process is limited to one bone, and this fact is explained on anatomic grounds—i.e., the fibrous tissue barrier between the suture lines prevents the extension of the infection The staphylococcus pyogenes aureus is the organism usually responsible, being present in 70 per cent of the cases, next in frequency is the streptococcus, found in 25 per cent, and in rare instances the staphylococcus pyogenes albus, pneumococcus, and other bacteria. Williams and Heilman (255) suggest the possibility that an anaërobic streptococcus may be the specific causative agent.

A consideration of the various potential avenues of infection is important if the appropriate prophylactic measures are to be instituted. However, it is often difficult in a given case to trace accurately the source of infection, in view of the fact that an early diagnosis is frequently impossible and pathologic specimens are not obtainable in the initial stages. There is considerable evidence to indicate that infection reaches the bones of the skull in one of the following ways (1) Directly (a) The process may be an extension from an infected paranasal sinus, the pus being forced into the adjacent bone because of inadequate drainage, or driven into the diploë as a result of the operation. The frontal sinus is the most common source of infection, owing to its more intimate relation to the diploic structures of the skull. It follows, then, that in cases of sinus infection prompt incision and prolonged drainage will tend to limit the extension of the process and permit the cavity to fill up with granulations. When drainage is instituted, the periosteum should be elevated as little as possible, curettage should be avoided and care should be taken not to open the diploë. (b) Less commonly osteomyelitis occurs as an extension of infection from a scalp or skull wound, especially following compound depressed fractures (although trauma is not as common a factor in the production of osteomyelitis of the skull as in that of long bones) Therefore, all cranial wounds should be meticulously débrided, and foreign bodies, such as comminuted bone, hair, and other extraneous particles which may act as potential foci of infection, carefully removed (p 272) (2) Indirectly Osteomyelitis of the skull may be hematogenous in origin and take the form of a metastatic infection during the course of an acute infectious disease.

Classification

Osteomyelitis of the skull may be classified as (1) *chronic discrete*, in which the infection is limited and has no tendency to spread, and (2) *acute diffuse*, or spreading Munro (181) believes that the pathologic process underlying both of these types is essentially the same, the difference in clinical features "being due to the rapidity and extent of the involvement of the venous channels in the diploë, and the resulting variation in the amount of bone destruction"

The *chronic discrete* variety has a tendency to heal by marginal sclerosis of the bone. When the overlying scalp is not lacerated, the infection manifests itself as a tender swelling—the so-called Pott's puffy tumor—which usually ruptures spontaneously with a discharge of pus. Its course is slow, with sequestration followed by healing, and a tendency on the part of the healed area to break down secondarily The condition is not dangerous unless perforation takes place into the cranium with the formation of extradural or subdural abscesses

The *acute diffuse* variety may be primary spreading from the very onset, or it may be secondary to, or superimposed upon, the chronic discrete. In the acute diffuse type the

early localized hyperemia and thrombosis are soon followed by the formation of pus foci in the diploe, due to the free anastomosis of the dural, diploic, and pericranial veins The infective organisms spread by means of a retrograde thrombosis in the veins or, more rarely, in the arteries (93) McKenzie (152) has shown that these organisms may travel through the Haversian canals along the outer and inner plates of the bone Once begun, the process quickly extends into the surrounding bone, which becomes soft and filled with granulation tissue and thrombosed veins In time the pus either perforates the inner table of the cranium and produces extradural and subdural abscesses, or it burrows through the outer plate and appears under the periosteum The prognosis is grave, and death frequently results from meningitis, brain abscess, sinus thrombosis, or septicemia

Diagnosis

Recognition of the *chronic discrete* type of osteomyelitis of the skull when once well established is not difficult There is a history of an infected focus, usually in the scalp If a scalp wound is present, there will be an offensive and purulent discharge, in the absence of such a wound, a fluctuating swelling develops over the affected site The constitutional phenomena are characterized by a low-grade fever, leukocytosis, and headache Roentgenographic examination reveals a clear-cut, moth-eaten appearance of the affected bone

In the *acute diffuse* variety a definite early diagnosis is difficult and often impossible The general constitutional symptoms are those of a severe toxemia *Edema* of the soft tissues over the affected part is the first local sign and is pathognomonic of the disease, the extent of the edema serving as a rough guide to the degree of bone involvement Mosher and Judd (174) stress the importance of this phenomenon, stating that "osteomyelitis writes across the patient's brow, not only the diagnosis, but the treatment" Roentgenographic examination is of limited significance, since it fails to disclose positive evidence of the inflammatory process until necrosis has taken place, and as this does not occur before the seventh to the tenth day following the onset of the disease, the process is often so far advanced when evidenced by the roentgenogram that treatment is no longer effective However, such an examination should not be omitted, as there is a possibility that it may reveal early rarification, in which event it will be of value in the corroboration of the clinical findings As soon as osteomyelitis is suspected, therefore, anteroposterior films should be made and the examination repeated at 2- to 3-day intervals King (128) believes that the softened decalcified region may be recognized several days before the moth-eaten appearance accompanying actual necrosis manifests itself, and he advocates exploratory drilling in addition to the x-ray examination to confirm the diagnosis The presence of a small opacity in the affected bone in a patient showing clinical evidences of osteomyelitis is, in his opinion, sufficient indication for operative interference

Prognosis

The outcome of the condition will depend upon the type of osteomyelitis and the nature of the infecting organism. The *chronic discrete* form offers a better prognosis than the *acute diffuse* variety. Infection due to the staphylococcus shows a mortality

of 21 per cent, whereas that due to the streptococcus shows nearly 100 per cent fatality (153, 259)

Treatment

Owing to the difficulty of foretelling the probable course of the infection, the early treatment of osteomyelitis of the skull is not standardized. There is a division of opinion concerning the choice between radical and conservative measures. During the past decade the surgical trend has been toward radical operation at the earliest possible moment, while the process is still localized and has had no time to spread to other parts of the skull and cranial contents. The principal advocates of this form of treatment are McKenzie (153), Imperatori (118), Bulson (31) Woodward (259) Munro (181), Wilensky (253), Fuerstenberg (93) and Mosher (173) They claim that once the osteomyelitic process has set in there can be no place for watchful expectancy or conservative measures, such as simple drainage by incision trephining, etc., applied in the hope that the process will remain self limited. They advocate wide removal of the entire thickness of all diseased and doubtful bone, going well into healthy tissue, followed by the opening of all abscesses, removal of necrotic tissue, and drainage of the exposed pachymeninx. McKenzie (152) summarizes their views in a telling phrase "Wheresoever the disease has spread there must the surgeon follow it." These investigators point out that the necessity of sacrificing large sections of bone should not deter the surgeon from recourse to wide excision, since the subsequent deformity can be corrected later by a plastic operation (p 585)

There are still those, however, who favor a more conservative course, in the belief that operative intervention during the acute stage of the disease opens up fresh channels through which the infection may spread to other parts. The chief exponents of conservative treatment are Blair and Brown (20), Hastings (110) and Dixon (60) They limit the early treatment to the draining of abscesses and refuse to operate until the acute infection has subsided and the patient's natural resistance has been increased, and even then they resort only to the removal of sequestra, refraining from opening the pachymeninx unless there is definite indication of a localized subdural abscess.

If one were sure that the osteomyelitic process would remain of the localized sclerosing type, there would be no objection to conservative treatment. But unfortunately in the early stages there is no way of determining whether or not the condition will develop into the acute spreading variety with its attendant meningitis and abscess formation Therefore, it would seem logical to resort to prompt radical measures in all instances. If, however, the patient does not come under observation until the process has advanced to the stage where it can be definitely diagnosed as being of the localized type, conservative treatment is obviously the one of choice

Preoperative Care

Since the operation entails a considerable loss of blood, one or more preliminary blood transfusions should be given and a donor should be on hand during and after the operation Transfusions are especially advisable for patients who are already debilitated as a result of a previous sinus operation. Local anesthesia usually suffices. Occasionally, it will be found advantageous to reinforce its effect with a previous administra

tion of avertin, as this agent, aside from exerting anesthetic properties, serves to reduce the blood pressure and lessen the tendency to hemorrhage

Management of Chronic Discrete Osteomyelitis

In the case of local sclerosing osteomyelitis spontaneous evacuation of the abscess usually occurs externally as a result of necrosis of the outer plate of the skull Less frequently rupture takes place intracranially through absorption of the inner plate, causing pressure and infection of the brain If the abscess is subcutaneous, all that is necessary to secure drainage is to incise the overlying scalp, but if it lies in the diploe, the outer plate of the affected portion of the skull must be perforated with a drill and the opening enlarged with a bone forceps. The cavity is then packed with vaselin gauze and a sterile dressing applied and changed weekly Adelstein and Courville (1) advocate balsam of Peru as a dressing, because it is "slightly antiseptic," keeps the wound moist, and stimulates the growth of granulations. Should granulations become exuberant and show a tendency to close the draining sinuses, they are cauterized with a silver nitrate stick

The process of sequestration is slow, and its progress should be observed at monthly intervals by means of x-ray examinations Sequestra, if small, may be left to extrude spontaneously, but if large, they should be extirpated as soon as a line of demarcation has formed At the time of their removal all fistulous tracts should be exposed, in order that the pus may be emptied Following operation the wound usually heals promptly.

Management of Acute Diffuse Osteomyelitis

Exposure of Osteomyelitic Area. After the usual aseptic preparation, the infected area is exposed by turning down a large scalp flap, the incision being so planned that the subsequent scar will be concealed either within the eyebrow or along the hair line (fig 226). If the process is limited to one frontal bone, an incision is made beginning just above the medial extremity of the eyebrow, carried above the eyebrow to the outer canthus, then upward for a distance of 2 5 cm beyond the edematous scalp (128). Should both frontal bones be involved, the incision is made to extend from one lateral canthus to the other immediately above the eyebrows From the center of this horizontal incision a vertical incision is carried upward, and the two flaps thus formed are retracted outward (172, 173) Some prefer to expose the osteomyelitic area through a coronal incision This is begun 2 to 3 cm posterior to the lateral canthus, at the level of the helix, and is extended across the vertex 1 to 2 cm within the normal hair line, following its natural curve, and deepened down to the subaponeurotic layer, so that the flap may be easily reflected Although the latter incision necessarily divides the temporal arteries, its use is not contraindicated on this account, since an adequate blood supply is retained through the supra-orbital vessels While the scalp flap is being turned back, hemorrhage is apt to be profuse, and is best controlled by carrying the fascia over the bleeding vessels or applying Adson's clamps to the cut edges (fig 220).

Removal of Diseased Bone. With the skull exposed, all dead bone is removed throughout its full thickness as follows. With a hand trephine or an electric burr a row of drill holes is made in the sound bone 2 to 3 cm beyond the obviously necrotic

area (fig 222) If pus exudes through these perforations, the drill is set further back to insure complete removal of all infected bone (128) The holes thus made are connected by means of saw-cuts, and the section of bone is removed either in one piece or in sections. During the removal care should be taken to avoid injury to the pachymeninx and the sagittal sinus. The pericranium along the margins of the defect should also be preserved, in the hope that new bone will form and help to obliterate the defect. Hemorrhage from the bone is controlled in the customary manner (p 555)

McKenzie (154) exposes the bone through a coronal incision and with a gouge and mallet makes a gutter in the bone down to the diploë, following the course of the scalp incision. The groove is deepened at one point until a sufficiently large opening has

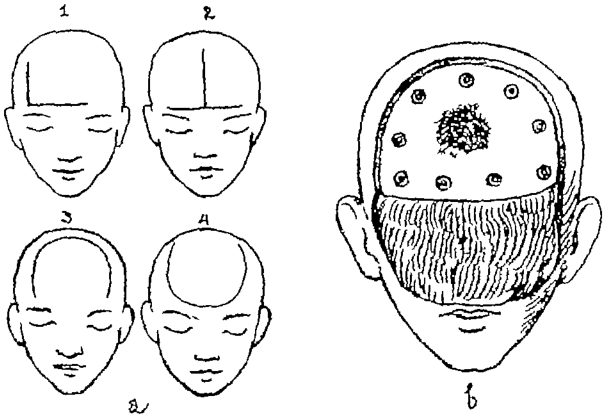


FIG. 226. Various incisions for exposure of osteomyelitic area of frontal bone. 1 L-shaped supra orbital incision. 2 Inverted T-shaped incision. 3 coronal incision within hair line. 4, turned-up forehead flap b forehead flap turned down, showing osteomyelitic bone. Area of bone to be removed outlined by drill holes

been made for the introduction of a bone forceps, with which the inner table at the base of the gutter is cut through. The forehead flap is then turned down over the patient's face, the bone above the supra-orbital ridges severed, and the section removed.

Mosher (173) to protect the pachymeninx and sagittal sinus in cases where the bone is unduly bowed, advises that the bone flap, instead of being removed in one piece, be excised in sections the first excision being carried only to the sinus. In this way easy access to the sinus is obtained and its separation from the bone facilitated.

Care of Wound. After the sequestrectomy the entire field is irrigated with normal salt solution The pachymeninx is inspected. Extradural and subdural abscesses, which are frequently encountered, are drained in the usual manner The defect is then packed with gauze soaked in some mild antiseptic solution, and the scalp flap is

loosely sutured back in place, the ends of the gauze pack being brought out between the stitches The ends are shortened daily, so that by the third to the fifth day the pack will be completely removed King (128) advises packing the wound with iodoform gauze soaked in a solution of azochloramid and suturing the scalp flap back into place as a precaution against shrinkage Following closure, irrigation with the same solution is instituted at 2-hour intervals At the end of 6 days the patient is placed under avertin anesthesia, and the flap is again raised, the packing renewed, and the flap replaced for another 4 days, at which time it is once more raised, all dressings removed permanently, and the flap loosely sutured into place Iodoform wicks are kept in the incision while healing is in progress Other types of wound dressings which have been suggested for the promotion of healing are bacteriophages (93), cod-liver oil ointment (144), "maggot enzyme," and allantoin (29).

Pastore and Williams (197) describe a case of the spreading type of osteomyelitis, in which they performed an external radical fronto-ethmoidectomy (Lothrop type), with a craniectomy of the frontal bone: "Incision of the skin was made over the vertex of the head from ear to ear, the pericranium was separated from the cranium to the frontal ridge and the entire frontal portion of the scalp was pushed over the eyes. A channel was cut through the bone down to the dura, well beyond the site of the osteomyelitis, which was easily identified The incision in the bone was carried down to the frontal sinus on both sides and across the wall of the brow, leaving a bony ridge above the brow The bone was dissected from the dura and over the left frontal lobe of the brain there was a large epidural abscess with widespread formation of granulation tissue . The posterior walls of both frontal sinuses were diseased and both the frontal and ethmoid sinuses were filled with pus and infected granulation tissue, all of which were removed A large opening into the nose was made through the floor of both frontal and both ethmoid sinuses and the openings were connected through the septum after the method of Lothrop Soft rubber tube drains were placed, one on each side, leading from the incision in the scalp down through the nose and out through the nostrils Rosenow's concentrated hyperimmune antistreptococcic serum, nos 261, and 262, diluted, were mixed and poured freely into the wound. A specific antivirus made from the organism found in diseased bone was later used daily for lavage of the wound The wound was closed with silk-worm sutures"

Supportive Measures

Supportive treatment must not be neglected and includes improvement of the general nutrition, attention to elimination and hygiene, heliotherapy in the form of ultraviolet irradiation, and of large doses of sulfanilamid Blood transfusions are of great value and are most effective if secured from an immune donor Some advise the administration of vaccines and antitoxins Dolman (61, 62) suggests the use of staphylococcic antitoxic serum, and others advise polyvalent staphylococcic toxoids (29). Complications are treated as they arise.

Plastic repair of the remaining deformity should not be attempted until 6 months to a year following recovery from infection, otherwise, there is a possibility that latent infection may flare up

ANOMALIES OF CRANIUM

Hydrocephalus

Hydrocephalus is a congenital or acquired condition characterized by an increase in cerebrospinal fluid volume either in the ventricular system (internal hydrocephalus) or in the space between the brain and the pachymeninx (external hydrocephalus) The latter variety is exceedingly rare and is probably always secondary to the internal type. The increased fluid volume may result from an overproduction by the choroid plexus, or from non-absorption of the fluid through the arachnoid villi, or it may be the result of a blockage in the pathway between the site of production and the site of absorption. As the volume of cerebrospinal fluid increases, the rising intraventricular pressure forces the brain against the unyielding skull, causing a pressure atrophy of the cortex.

Etiology

Etiologically, hydrocephalus may be classified as either (1) *non-communicating*, or (2) *communicating* *Non-communicating hydrocephalus* results from a blockage somewhere in the ventricular system, the fluid being prevented from passing into the spinal canal. The obstruction may be due to (1) a malformation, such as atresia or absence of one or more of the foramina through which the ventricles normally communicate, (2) an obstruction of the aqueduct of Sylvius by a distortion of the skull, such as occurs in achondroplasia, (3) a stricture caused by the organization of an inflammatory exudate, or (4) a neoplasm. The usual site of the blockage is the foramen of Monro, located between the third and lateral ventricles If only one foramen is involved, there will be a distention of the corresponding ventricle If, however, the obstruction affects both foramina or is situated within the third ventricle or in the area of its communication with the fourth ventricle (aqueduct of Sylvius) or in the fourth ventricle itself, the distention will be bilateral.

In the *communicating type* of hydrocephalus the passage of cerebrospinal fluid into the subarachnoid space is unobstructed, but a blockage in the basal cisterns prevents the absorption of the liquid. Thus, it can leave the ventricular system by way of the foramen of Magendie and Luschka and proceed into the spinal subarachnoid space, but it cannot pass upward over the convexity of the hemispheres to be absorbed by the arachnoid villi.

Clinical Features

The symptoms of hydrocephalus depend upon the age of the patient and the degree of intracranial pressure. If the condition is congenital, the sutures yield to the intracranial pressure and the bones separate, causing a marked deformity of the skull. As long as this separation is able to compensate for the increasing intracranial pressure, cerebral compression symptoms are absent. The head presents a characteristic picture. The skull is enlarged, sometimes being of such a size that the child is unable to raise its head The forehead overhangs the face, which appears disproportionately small, and the fontanels bulge. The eyelids and scalp are stretched and are traversed by engorged and tortuous veins resulting from the increased intravenous pressure. Palpa

tion reveals fluctuation and bony crackling, owing to the thinning of the bone, and percussion often elicits a "cracked-pot" resonance The child seldom cries, because crying increases the intracranial pressure If he survives, there is usually a greater or lesser degree of mental retardation While the skull is spreading and compensating for the rising fluid volume, most of the symptoms of increased intracranial pressure, as previously stated, are absent, although optic atrophy and blindness are not of infrequent occurrence, and in rare instances the child becomes obese, due to the pressure of the fluid on the hypophysis In time the skull can no longer withstand the increasing intracranial pressure, and symptoms of cerebral compression supervene

In the acquired variety the shape of the head is not altered, since the skull is incapable of expanding in response to the increasing pressure within the cranium. Therefore, pressure symptoms, such as headache, projectile vomiting, papilledema, etc (p. 527), are common and appear at an early stage, due to the pressure of the enlarged brain against the unyielding skull.

Diagnosis

The treatment must obviously be governed by the nature of the causative factor and its location, but unfortunately even with all the diagnostic tests available such a determination is difficult and often impossible. The methods adopted to locate the site of obstruction are (1) *lumbar puncture,* (2) *ventricular puncture,* (3) *phenolsulphonephthalein test,* and (4) *roentgenographic visualization* of the ventricular system after the injection of air

Lumbar Puncture. If a manometric examination of the spinal fluid following lumbar puncture shows a normal or subnormal pressure, it is indicative of the so-called non-communicating or internal variety of hydrocephalus, due to an obstruction somewhere between the ventricles and the subarachnoid space in the cord If, on the other hand, such an examination reveals a greatly increased pressure, it points to the communicating type A more accurate estimation of the source of obstruction can be obtained if the lumbar puncture is accompanied by a ventricular puncture and the findings compared. Should the two readings agree, there is evidence of a communicating hydrocephalus, but if the ventricular pressure is high and the spinal subarachnoid pressure low, the condition is probably non-communicating

Ventricular Puncture. Ventricular puncture followed by an estimation of the amount of fluid withdrawn will indicate the presence and degree of dilatation of the ventricles and will also show whether the involvement is unilateral or bilateral Normally, the ventricle contains from 10 to 15 cc of fluid, the finding of a quantity exceeding 30 or 40 cc is suggestive of dilatation.

Phenolsulphonephthalein Test. Another method of differentiation of the communicating from the non-communicating variety is by means of the phenolsulphonephthalein test of Dandy and Blackfan (57). One cc of neutral phenolsulphonephthalein is introduced into the spinal subarachnoid space In 20 to 30 minutes the fluid is aspirated from the ventricle, and a few drops of sodium hydroxid are added to the liquid If it remains colorless, it indicates that there is an obstruction in the upward diffusion of the fluid If, however, a pink color appears, it shows that there is a communication between the subarachnoid and ventricular spaces. One cc. of the dye may also be injected into the lateral ventricle and a lumbar puncture made 10 minutes later. The

fluid is then tested as above with sodium hydroxid for the presence of the dye Obviously, an absence of color in the fluid denotes an obstruction in the passage.

Roentgenographic Visualization. (1) *Encephalography* The patient is placed in the sitting position a lumbar puncture is made, and cerebrospinal fluid is removed The removal should be gradual, lest a too sudden reduction in the intraspinal pressure induce herniation of the brain into the foramen magnum. The quantity withdrawn is replaced with air, and a roentgenogram of the skull is made. If the hydrocephalus is of the communicating type, the plate will show air in the lateral ventricles, conversely, if it is of the non-communicating variety, there will be no evidence of air

(2) *Ventriculography* Cerebrospinal fluid is withdrawn from the lateral ventricle by the introduction of a needle through an open fontanel, a suture, or a trephine opening The liquid is replaced with air, and a roentgenographic skull plate is made. The plate will show not only the amount of ventricular dilatation, but also the presence of asymmetry, which will help to localize the site of the obstruction (56)

Treatment

The need for treatment of hydrocephalus is conceded, since the increase in the intra cranial pressure, if allowed to progress, will in time cause a destruction of the brain tissue. The optimal time for operative interference will be governed by the rapidity of the hydrocephalic process. Dandy (55) states "Since the brain is so rapidly destroyed by advancing hydrocephalus, it is important that delay be avoided when further surgical efforts are to be instituted In this connection it should be emphasized that unless hydrocephalics are brought very early for treatment, attempted cures are not worth while There is no point in curing or attempting to cure a baby that is certainly going to be subnormal mentally For the rapidly growing hydrocephalics, three months is the outside limit for surgical intervention, for those that are growing less rapidly, the limit may vary from six months to a year, all depending of course, on the actual size and rapidity of the growth of the head. But the earlier the treatment the better the results, both in terms of life and of subsequent mentality "

A great many methods have been suggested for the relief of hydrocephalus as is usually the case when the pathogenesis of a condition is not quite clear, but the results thus far have been generally discouraging The only exceptions are those instances in which there is a definite obstruction which can be attacked directly For example, a tumor in the vicinity of the foramen of Magendie and Luschka (50 51) may be surgically removed through a suboccipital osteoplastic flap reflection, and multiple tumors in the meninges are often successfully treated by deep Roentgen irradiation. Dandy (54) states that "all forms of therapy have been entirely empirical. They have been directed toward the effect rather than the cause. They have lacked not only the etiology and pathology of the disease but even a knowledge of the circulation of cerebrospinal fluid before pathological changes have occurred."

The problem has been attacked in a variety of ways

Paracentesis. Attempts have been made to remove the excess fluid by paracentesis of the lateral ventricles. While this affords temporary relief it is said to be followed sooner or later by meningitis. The lateral ventricles may be tapped through the lateral angle of the anterior fontanel or through a trephine opening In the former case a fine trocar and cannula is inserted 2.5 cm. from the midline, gradually forced toward

the base of the skull for a distance of 5 cm., and the fluid allowed to escape through the cannula. If the latter method is chosen, a scalp flap is turned down from behind the ear, and with a trephine a disk of bone is removed at a point 3 cm behind the external acoustic meatus and 3 cm. above Reid's base line Without opening the pachymeninx the trocar and cannula is inserted in the direction of the lateral ventricle for a distance of 1 to 2 cm The trocar is then removed and the liquid permitted to escape

Drainage. Attempts have been made to divert the fluid from the ventricles to some other part of the body which will permit of its absorption

(1) Into the *subdural space, the subaponeurotic layer of the scalp, or the neck tissues,* by means of threads introduced subcutaneously This method was advocated by Mikulicz (162) and the technic is as follows: The pachymeninx is exposed either through an open fontanel or through a small trephine opening behind the ear. A trocar and cannula is inserted into the lateral ventricle, the trocar is removed, and a small amount of cerebrospinal fluid is withdrawn through the cannula Several strands of tied suture material are introduced through the cannula into the ventricle. The cannula is removed, and the free ends of the sutures are laid either in the subdural space, the subaponeurotic tissue of the scalp, or the soft tissues of the neck The use of threads was later superseded by recourse to tubes of gold and platinum which were thought to permit of better drainage (10) However, both of these methods were soon abandoned, as it was found that any relief of pressure which they afforded was only temporary, since the lymphatics soon became obstructed and prevented further absorption of the fluid In addition, it was discovered that foreign body reactions were set up in the tissues

(2) *Into the retroperitoneal tissues* Cushing (46) drained the lumbar theca into the peritoneal cavity by passing a cannula through the body of the fifth lumbar vertebra

(3) Into the *sagittal (superior longitudinal) sinus* Payr (198) created a communication between the lateral ventricles and the superior longitudinal sinus by grafting between these spaces a section of the saphenous vein. This method of drainage, like the previous ones, was unsuccessful, however, since the graft soon lost its patency.

(4) Into the *urinary bladder* (fig 227) The most promising of these procedures seems to be that advocated by Heile (111) who diverts the flow of cerebrospinal fluid into the urinary bladder One kidney is removed, the pelvis being left attached to the ureter. Through a laminectomy of the lumbar vertebrae an opening is made into the abdominal cavity. The ureter, guided by silk threads attached to its upper end, is drawn through The pachymeninx of the lumbar cord is opened, and the end of the ureter, which has been previously divided into three flaps, is carefully sutured to the margins of the dural wound The operation is completed by closure of the laparotomy and laminectomy wounds The operation seems logical, inasmuch as the ureter is a natural drainage tube, and because the patency of the anastomosis is likely to be preserved, since there has been no interference with the blood supply. Furthermore, should ureteral peristalsis be retained in the transplanted ureter, it would aid in the elimination of the fluid However, the method has not as yet been used long enough for a proper estimation of the effect of a continuous loss of cerebrospinal fluid, nor is it possible at the present time to determine whether or not a ureter separated from the kidney will retain its patency indefinitely Moreover, the operation necessitates the loss of one kidney and is naturally contraindicated if there is any evidence of renal impairment It would seem that the procedure could be simplified by the creation of

an extraperitoneal anastomosis between the ureter and the pachymeninx without the necessity of opening the abdominal cavity

Reduction of Formation of Cerebrospinal Fluid Other attempts to solve the problem in the communicating type of hydrocephalus have been directed toward bringing about a reduction in the amount of cerebrospinal fluid secreted. This is accomplished by a destruction of the choroid plexus either by means of Roentgen irradiation or by cauterization. Dandy (55) advocates "(1) The cauterization with or without removal of the choroid plexus lying in the posterior cranial fossa namely, that in the fourth ventricle and along both flocculi (fig 228), and (2) cauterization of the plexus

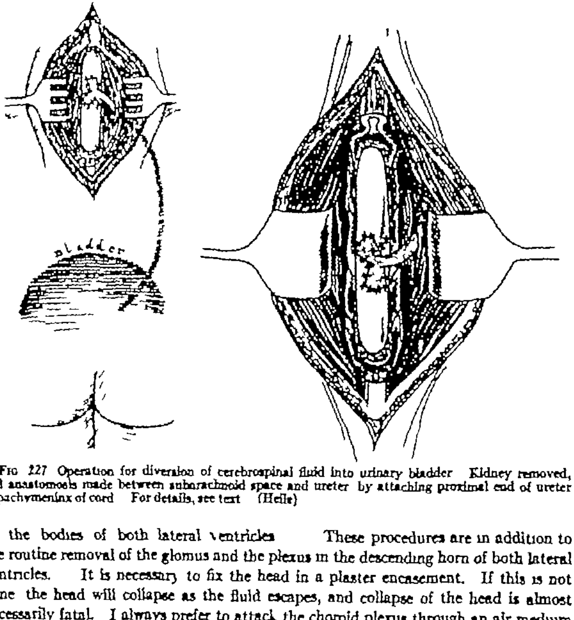


Fig 227 Operation for diversion of cerebrospinal fluid into urinary bladder Kidney removed, and anastomosis made between subarachnoid space and ureter by attaching proximal end of ureter to pachymeninx of cord For details, see text (Heile)

in the bodies of both lateral ventricles These procedures are in addition to the routine removal of the glomus and the plexus in the descending horn of both lateral ventricles. It is necessary to fix the head in a plaster encasement. If this is not done the head will collapse as the fluid escapes, and collapse of the head is almost necessarily fatal. I always prefer to attack the choroid plexus through an air medium because it is much more simple the plexus is so much better seen and so much easier of cauterization and removal. The cutaneous incision is straight and vertical (about 2 cm in length) in the occipital region of each side and about 2.5 to 3 cm from the midline The bone is ronguered away until its opening is

almost exactly the size of the small ventriculoscope After opening the dura and cauterizing any cortical vessels, the underlying cortex is incised and the ventriculoscope is introduced into the posterior horn of the ventricle . The ventricular fluid is collected, kept warm and replaced at the end of the operation After much experimentation the Cameron light has been found to be much the most satisfactory. The illumination of the ventricle is almost perfect and without sacrificing room in the tube In order to prevent the effects of the electrocautery from spreading, an insulated German bakelite tube is used In recent years I have usually, but not invariably, removed the glomus of only one ventricle at a time Usually an interval of a week between the right and left sides is sufficient The best method of attack upon this mass of

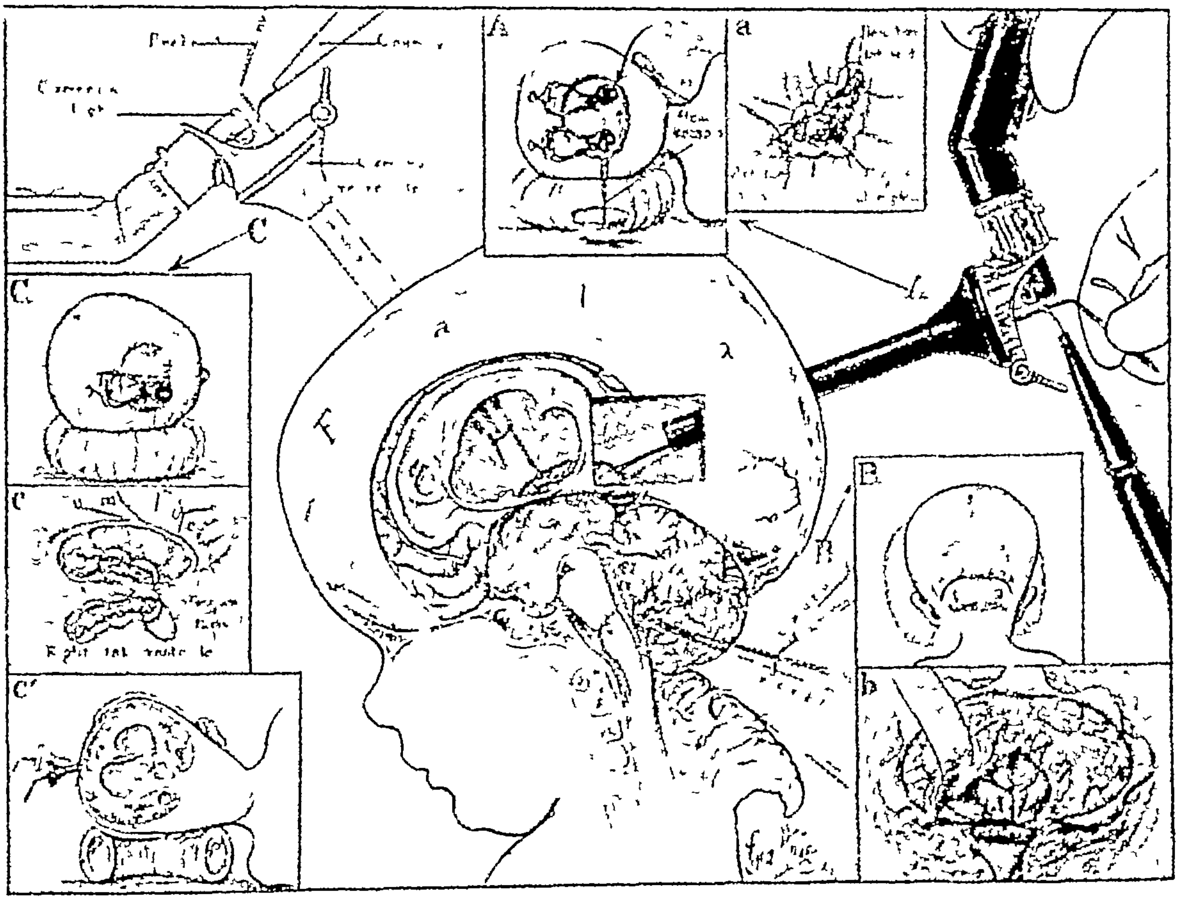


FIG 228 Cauterization of choroid plexus *a*, glomus of choroid plexus *b*, choroid plexus in posterior fossa *c*, *c*, *c'*, choroid plexus of lateral ventricle For details, see text (Dandy, Ann. Surg , 1938)

dangling choroid plexus—the glomus—has also been determined only after much experimentation It can be aspirated (only in young babies) into a continuous suction tube very easily and with scarcely any bleeding because the vessels of this age are small and contract promptly H[illegible]r, it is probably preferable to cauterize the mass by applying a meta probe [illegible] ce until it is greatly shrunken . This mass can then [illegible] [illegible]er bladed forceps, or sucked through the tube, or even [illegible] [illegible]de to [illegible]erize that portion of the choroid plexus [illegible] d [illegible]d also that in the body of the lateral ve[illegible] [illegible]terize the plexus far beyond the bend [illegible] [illegible]ing the ventriculoscope, the ventricu[illegible] Ringer's solution .

"Exposure of the posterior cranial fossa by a small bilateral suboccipital craniotomy brings all of the choroid plexus in this region immediately into view Extirpation of the choroid plexus from the bodies of the lateral ventricle is not possible because the plexus is but slightly elevated. However, it is only necessary to lightly draw the coagulating needle of the electrocautery (or better a probe which is touched by the cautery) along it to the foramen of Monro, to see it shrivel to a white streak. It has seemed better to coagulate this part of the plexus on both sides at a single sitting To accomplish this end the same sized Cameron ventriculoscope is passed through the right side of the anterior fontanelle, which is always large. The air medium is also used in the attack upon this part of the plexus. Usually the septum pellucidum is already perforated, or even largely destroyed by the pressure of the hydrocephalic fluid. It is then only necessary to shift the ventriculoscope through the openings to expose the choroid plexus on the left side. But if no perforation exists one of adequate size can easily be incised with the cautery"

Congenital Cerebral Hernia

Congenital cerebral hernia, a condition characterized by a protrusion of the cranial contents through a congenital defect in the skull, is a rare anomaly, occurring once in every 4000 births. It is said to be due to a defective development of the mesoblastic tissue outside of the primitive cerebral vesicle, resulting in extracranial exposure of a part of the brain or its membranes. The condition is usually associated with other malformations, the most common being hydrocephalus, spina bifida, cleft lip and palate, club-foot, and congenital dislocation of the hip

The outcome is usually tragic. If the bone defect is large and much brain substance is involved, the condition is incompatible with life, the child either being stillborn or dying soon after birth. In less serious cases the majority of victims die within the first 2 years of an infective meningitis, hydrocephalus, or convulsions, and those who live beyond that time are either partially paralyzed or idiotic. Occasionally, the condition remains stationary, and in rare instances the subsequent growth of the cranial bones closes the opening, the hernia remaining as a cyst, with its base fixed to the skull.

Cerebral hernias are usually classified structurally into (1) meningocele, consisting of a hernia of the brain-coverings, (2) encephalocele, wherein there is a protrusion of brain tissue, and (3) hydrencephalocele, wherein the protruding sac contains meninges, brain tissue, and cerebrospinal fluid. In the latter variety the brain tissue often communicates with the lateral ventricles.

Cerebral hernias range in size from that of a pea to a cocoanut, and occur almost invariably in the midline Their most common site is the occipital region, although not infrequently they are found at the root of the nose, over the fontanels, or along the sagittal suture, and occasionally at the base of the skull. In the latter case the sac can be seen projecting into the mouth, nose, or pharynx. If the tumor is small, the overlying skin may be normal or thickened and can be readily separated from the sac during operation, but if large, the skin may have become atrophied to a parchmentlike thinness, and the greatest caution will be necessary during examination and operation to prevent its rupture. Regardless of the size of the mass, the superficial blood vessels are likely to be tortuous and dilated. The tumor pulsates with respiratory movements and increases in size on expiratory effort, such as coughing or crying It may be partially reducible, in which case the margins of the opening in the cranial defect can

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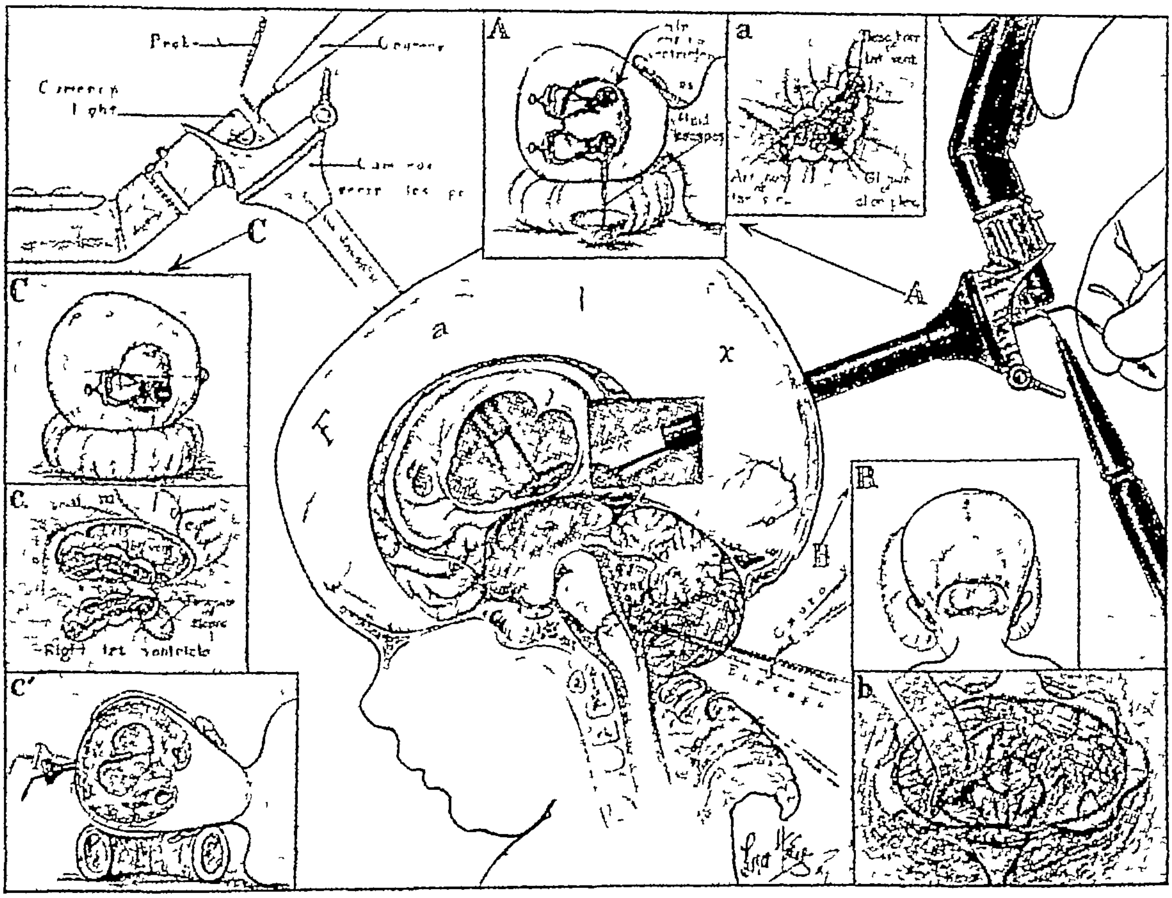

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be palpated. Reduction, however, should be done gradually, so as to avoid the consequences of a too sudden increase in the intracranial pressure

Surgery is justifiable only in selected cases It is contraindicated if the mass is large and includes much brain tissue, and when the condition is associated with other gross developmental faults, such as hydrocephalus and extensive spina bifida The most favorable types of hernia for operation are small meningoceles, and even here the operative mortality is 50 per cent (40, 165) Therefore, before any decision is reached, a searching examination must be made to determine the degree to which the central nervous system is involved, and the location, size, and composition of the hernia

The size of the bony defect and the presence or absence of brain tissue in the sac may be determined by palpation of the tumor after the fluid has been aspirated or the contents emptied into the cranial cavity If the defect in the skull is small, it is not likely that a large amount of brain substance has protruded The consistency of the sac gives valuable aid, if it feels empty and appears translucent after reduction, it may be assumed that no brain tissue is present Roentgenographic examination is of the greatest importance in the determination of the nature of the cranial defect. It will also reveal the contents of the sac after the fluid has been replaced with air

Treatment

Time of Operation. The optimal time for surgical intervention is a matter of dispute Some surgeons prefer to postpone operation until the child has reached the age of 1 or 2 years. Others believe that many lives can be saved by early operation, in view of the fact that 80 per cent of the untreated cases die during the first year They advocate operation immediately after birth, provided the general condition of the infant is good If at birth, however, the sac is found to be so thin that rupture seems imminent, or if it has already ruptured, they operate at once, regardless of the infant's general condition, since this offers the only chance of averting septic meningitis

In those cases where operation is delayed pending a general improvement in the infant's condition, every precaution should be taken to prevent rupture of the sac But if, despite such precautions, rupture takes place or the overlying skin becomes ulcerated, surgical intervention should be deferred until all local infection has cleared up and the ulcer has healed

Technic. The sac may be removed either under local or general anesthesia Special precautions must be taken to prevent shock and minimize the loss of blood

A skin incision is made around the pedicle of the sac in such a manner that sufficient scalp will be left after the excision to cover the defect without tension (fig 229) When the skin is normal, this affords no difficulty, indeed, even when the skin is atrophied and must be cut away with the sac, enough usually remains to permit of direct approximation The skin on the proximal side of the incision is dissected from the meningeal sac, care being taken to avoid its perforation—an accident which might induce shock from the sudden loss of cerebrospinal fluid To limit the loss of blood, all vessels are clamped and ligated as soon as they are cut [illegible] in separation has been carried down to the defect in th[illegible] the neck of [illegible] sac is dissected free from the bony margin of th[illegible] the [illegible] uinal hernia The pedicle, regardless of its possi[illegible] con[illegible] with chromacized catgut, since such tissue in a [illegible] gib[illegible] less. [illegible]c is then cut

away The stump of the pedicle is sutured over as a precaution against leakage and is allowed to fall into the cranial cavity Von Bergmann (250) advises that the sac be left in place but folded over on itself and used as a prop to cover the opening Finally, a flap of the contiguous pericranium is turned over on a hinge, smooth surface inward, and sutured to the pericranium on the opposite side. The soft tissues are then united in layers over the defect. The cranial defect itself may be reconstructed at a later date with a bone or cartilage transplant (p 585) The operation is often followed by an increase in the intracranial pressure This usually subsides in a short time, but in some cases it may be so serious as to necessitate a lumbar puncture.

Cone (39) advocates preservation of the meningeal sac, as he believes that it aids in the absorption of cerebrospinal fluid (48) and that its removal predisposes to hydrocephalus. He operates essentially as follows 'A circular incision is carried around the body of the protrusion so as to preserve as much good skin as possible. The skin above the incision is peeled off to the apex by sharp dissection. The skin below the incision is then reflected from the sac until the neck of the sac is freely exposed passing

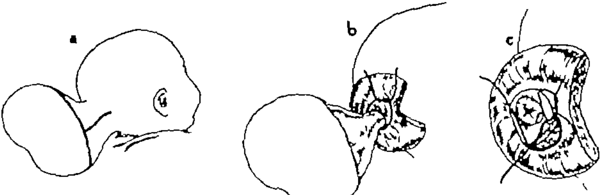


FIG 229 Operation for removal of meningocele. *a*, incision. *b* skin on proximal side of incision dissected from sac to bone defect, and pedicle of sac ligated. *c* flap of pericranium turned over to cover skull opening.

into the defect of the skull. The sac is then opened widely enough to allow inspection of its contents. When the sac of the meningocele contains a cavity, as it usually does, the fluid is evacuated and the incision is then closed with interrupted sutures. If the sac contains only spongy tissue with small loculi, fluid will escape from it when it is cut across and it is treated in the same manner The collapsed and closed sac is rolled up or placed in a heap It is impossible to get it all into the cranial cavity Instead, it is left in situ and a fascial tent is made over it. The tent of protective fascia may be secured from the fascia lata of the father's thigh. In most cases, however, the sac is not too great in volume to be covered by flaps of deep fascia which carpets the adjacent bone and mucle of the infant. These flaps are cut and turned over the sac, the attachment to the bony defect being preserved. In some cases the sac itself has a dense capsule near its base and if it is rolled over on itself the uppermost wall of the sac proper will serve as a tent, if the edges are fastened to the deep fascia by interrupted sutures. A further fascial layer may or may not be sutured over this. Buried sutures are then taken to approximate the skin edges so that the skin can be

sutured without tension. . . We usually institute drainage for 24 hours through a stab wound and use silk sutures throughout."

Microcephalus

An abnormally small cranium is usually associated with idiocy and is now believed to be an anomaly secondary to defective cerebral development and not, as was formerly thought, a primary condition due to premature ossification of the sutures The brain in the course of its normal development increases the capacity of the cranial cavity It is only when the brain tissue fails to enlarge that premature ossification of the sutures can take place Confusing cause and effect, Lannelongue (137) (1890) suggested that an attempt be made to relieve the condition by the removal of portions of the cranium, hoping thereby to give the brain an opportunity to expand. This procedure aroused much interest, and a number of cases were submitted to linear craniectomies, but for obvious reasons the results were unsatisfactory, and today the operation is one of historical interest only.

Craniostenosis

Craniostenosis is a term which has been made to include a heterogeneous collection of skull deformities due to premature fusion of one or more of the cranial sutures The affected part fails to develop, and a compensatory bulging takes place elsewhere in the skull. According to Virchow (248) (1851) "Normal growth is inhibited in a direction perpendicular to the obliterated line of suture and compensatory growth takes place in other directions " The type of deformity and its extent depends upon the location and number of the sutures affected and the age at which fusion takes place

The types most commonly encountered are (fig. 230) (1) *Oxycephaly*, characterized by an increased vertical diameter of the head, a high, broad forehead, and a flattened occiput It is due to a fusion of the sagittal and coronal sutures, the growth of the vault being restricted in its anteroposterior and transverse diameters (2) *Acrocephaly*, a deformity similar to oxycephaly, except that the head presents a pointed rather than a rounded contour (3) *Turricephaly*, or "steeple skull" (Turmschaedel), in which the skull is deformed at or near the anterior fontanel (4) *Scaphalocephaly*, in which the head is boat-shaped, due to a closure of the sagittal sutures with a compensatory overgrowth at the coronal and lambdoidal sutures (5) *Plagiocephaly*, or "lop-sided head," distinguished by an asymmetry of the skull and due to unilateral premature synostosis of a temporoparietal suture

Craniostenosis may be present at birth or may not manifest itself until the second or third year The exact cause of the premature fusion of the sutures is unknown It has been variously attributed to inflammation of the meninges (248), inflammation of the cranial bones (107), rickets (149), a too close proximity or dislocation of the ossification centers of adjoining bones (171, 216), and hypophyseal and glandular disturbances (19) Heredity likewise seems to have some bearing on its production (41).

Oxycephaly is the most common form of craniostenosis The head presents a characteristic appearance The vertical diameter is greatly increased, the skull is high and narrow, and the forehead towers over the face The superciliary and temporal ridges are feebly marked, the orbital cavities are shallow, tending to force the eyes out of

their sockets (exophthalmos), the nasal septum is deviated, the hard palate is arched, and the face is narrow and asymmetrical. Greig (102) states "Oxycephaly cannot evade observation, even in its slightest form it attracts attention, whilst in its grosser forms should the individual survive, there is no passer by but is shocked by the dis-

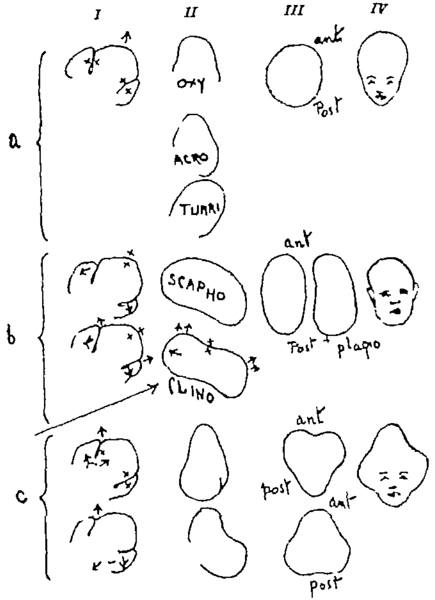


FIG. 230 Types of craniostenosis. *I* showing site of stenosis (*x*) and direction of compensatory growth (→) *II* profile view *III* horizontal view *IV* frontal view *a*, *oxycephalic group* due to fusion of coronal and lambdoidal sutures, with growth of vault restricted in anteroposterior and transverse diameters. Oxycephaly, in which vertical diameter is increased. Acrocephaly same, except that head is pointed, rather than rounded. Turricephaly skull deformed near anterior fontanel. *b*, *scaphalocephalic group* due to synostosis of sagittal suture and one or other temporoparietal suture. Clinocephaly in which vertex is hollow *c*, *plagiocephalic group*, due to delayed closure of fontanels. Skull asymmetrical and heart-shaped. (Sear Brit. Jour Rad., 1937)

figurement, and repelled by the hideousness." The sense of sight and smell are impaired and frequently lost. Headache is common, but there is little or no mental deficiency In time symptoms of intracranial pressure appear, marked by optic atrophy, divergent strabismus, and nystagmus Roentgenographic examination of the skull reveals the premature synostosis, the thinning of the bones due to pressure of

the expanding brain, and a honeycombed appearance resulting from the pressure of the cerebral convolutions

Many operations have been suggested for the alleviation of this condition, among which are subtemporal decompression on one or both sides, linear craniectomy (75, 140), circular resection (13), and resection of the optic canals (72) While these procedures may serve to relieve the intracranial pressure, unfortunately they do not permit of a symmetrical expansion of the skull or of a normal growth of the brain

King (127) describes a new operation which he performed in two stages on a boy of 8 years "A flap consisting of scalp, galea, temporal fascia and muscle, and the pericranium was turned down This flap was horseshoe-shaped, attached in the temporal region, and included almost all of one side of the head Burr holes were made about the periphery of the skull exposure about 2 inches apart, and several other burr holes were made in the central part of the exposed skull With a deVilbiss forceps, channels were cut connecting the holes, and the bones of the cranial vault were cut into triangular and rectangular shapes, creating a 'mosaic' The bone fragments varied in size from one and three-quarters to two inches on a side. Bleeding from the scalp flap was controlled by the use of a pedicle clamp and skin clips. The dura was not opened It was very thin, transparent, and redundant The bone fragments separated widely, one fragment from another The scalp flap was returned to its position over the morsellated skull fragments and sutured in two layers, without drainage A copious dressing was applied and covered with a plaster shell Upon completion of this first stage of the operation it was observed that the operated side of the head gave a rounded contour, as compared with the roof-like appearance of the unoperated side. The exophthalmos on the operated side had receded to a marked degree, in fact, had almost disappeared, and that on the unoperated side had greatly diminished The boy made an uneventful recovery Six weeks later the other side was operated upon in the same manner Vision, which had been very poor, was markedly improved The head had a normal rounded contour The bone fragments on both sides of the cranial vault were firmly united The boy's apathetic appearance had changed to that of alertness This is only a preliminary report It is hoped that a later and favorable report can be made"

Aplasia Cranii Congenita

Aplasia cranii congenita is a congenital defect due to incomplete ossification of the cranial bones In individuals so afflicted trivial skull injuries are apt to bring about severe brain damage Although nothing can be done to promote normal development of the bones, the condition suggests a strengthening of the cranial vault by means of cartilage or fat implants

NEOPLASMS OF SKULL

Inasmuch as no important muscles are attached to the skull, cranial tumors may be widely excised without the usual danger of functional impairment. The removal of these growths, however, entails the danger of injury to the brain Therefore, a careful preoperative study of the growth should precede any attempt at its excision While clinical symptoms are important, they are frequently unreliable indices of cerebral encroachment For instance, there may be extensive damage to the skull over a "silent area" of the brain with no clinical signs of cerebral irritation Furthermore,

it is often impossible, during operation, to determine the surface limits of the tumor growth, the degree of bone expansion, and the extent of infiltration into the outer or the inner plates of the skull, the pachymeninx, or the brain It is only by a meticulous preliminary roentgenographic examination that these facts can be accurately estimated

The neoplastic growths most frequently found on the skull are (1) osteoma, (2) sarcoma, and (3) metastatic carcinoma.

Osteoma

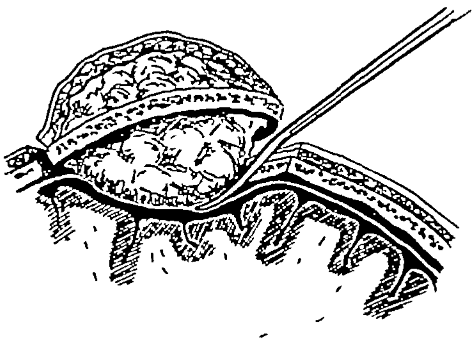
Osteomata of the skull are seen either on the frontal bone in the vicinity of the frontal sinus and roof of the orbit, or in the temporal bone, especially in the region of the external acoustic meatus. They arise either from embryonic cartilage cells at the junction of the ethmoid and frontal bone, from the periosteum, or from a calcified polyps in the sinus. Structurally, they are either (1) compact (hard or eburnated) or (2) cancellous (spongy) Since the compact variety arises in bones which have developed from membrane, it is naturally the type most commonly found in the skull. The growths are of an ivory consistency and sessile, and were brilliantly described by Paget (192) in 1851 "Their nodular form and uniform hard, ivory like texture, their growth in the diploë or sinuses as isolated or narrowly attached masses, their tendency to extend in all directions, their raising and penetrating the bones of the skull, and growing into the cavities of the skull and orbit, all show the exceeding difficulty and perils of operations on them."

Osteomata are comparatively rare tumors and of slow development. In the skull they usually remain limited to the outer plate, but they may spread and encroach upon the frontal sinus, external acoustic meatus, or orbital and cranial cavity, injuring or destroying the brain or eye. When small, they occasion no symptoms. The patient seeks advice only when they have reached such dimensions as to produce deformity, obstruct drainage, or give rise to pressure symptoms.

Technic of Removal The removal of osteomata limited to the *outer plate of the skull* is comparatively simple. A scalp flap is turned down over the site of the tumor (p 586), and the osseous growth, including a section of surrounding healthy bone, is chiseled off Hemorrhage, which is usually moderate, can be controlled by tampon pressure or by means of Horsley's wax plugged into the bleeding points. If the defect after excision of the tumor is large or is located in a conspicuous area such as the forehead, the contour must be re-established by the introduction of a graft of fat, cartilage, or bone, shaped to fit the defect. This procedure may be carried out at once or may be deferred to a later date. The operation is terminated by a replacement of the scalp flap

If the tumor involves the entire thickness of the cranial bone, its removal by means of a chisel and hammer is undesirable, as the trauma thus occasioned may result in concussion of the brain. A better plan is the following A scalp flap is turned down in the customary manner, and with a Hudson perforating burr a series of trephine openings is made in the unaffected bone around the tumor (fig 222) As each hole is completed, a cotton plug is introduced for the control of hemorrhage. A *gigli* saw, threaded on a metal guide, is inserted into one of the burr openings and so manipulated that it will emerge at another opening some distance away where it is withdrawn. The saw handles are then attached and the saw worked to and fro, cutting through the

bone between the holes, until the section is completely freed Throughout the procedure the metal guide remains between the pachymeninx and the skull to prevent injury to the membrane Before the section of bone is removed, it is freed from the underlying pachymeninx by means of a dural separator (fig 231-I) If the tumor crosses a skull suture, its separation is apt to occasion serious hemorrhage The tumor can usually be separated cleanly from the pachymeninx, but in some cases its removal will necessitate the inclusion of a portion of the membrane or even a part of the brain Under such circumstances bleeding from the pachymeninx is controlled by underrunning the vessels with fine silk sutures or by clamping them with metal clips Diathermic coagulation may be resorted to if the vessels are small and not situated over the motor area or in the neighborhood of a sinus where a thrombus would be likely to form Bleeding from the cortical vessels may be checked by means of metal clips or by pressing small pieces of muscle against the bleeding points The defect remaining in the skull is reconstructed as described on page 585 The operation is completed by replacement of the soft tissue flap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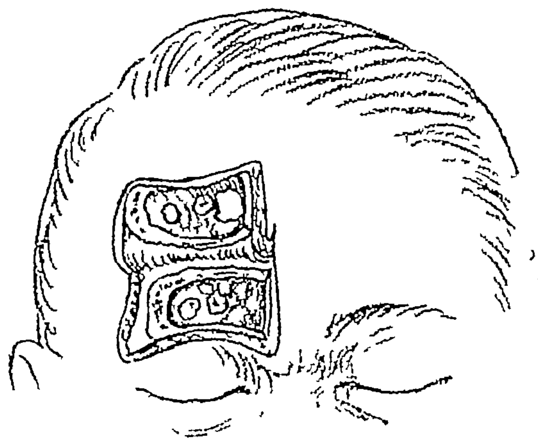
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FIG 231 Removal of osteoma from skull *I*, from cranial vault Tumor circumscribed by series of drill holes made in surrounding healthy bone Bone between drill holes cut through with gigli saw Tumor mass bluntly separated from pachymeninx and removed (Kirschner) *II*, from frontal sinus Osteoplastic flap reflected upward and tumor chiseled away (Perthes)

If the tumor involves the *frontal sinus*, Perthes's (199) approach affords the best exposure (fig 231-II) A horizontal incision carried down to the bone is made along the lower border of the eyebrow, beginning at the level of the outer canthus and extending to the glabella From the ends of this incision 2 vertical incisions 2 to 3 cm long are carried upward A fine chisel is placed against the bone, and the outer wall of the frontal sinus is progressively cut through With a stout periosteal elevator the pedicle of the bone flap is fractured and the osteoplastic flap laid back to expose the frontal sinus Hemorrhage is controlled either by tampon pressure or by means of Horsley's wax plugged into the bone If the tumor is found to be pedunculated, it is severed at the pedicle, but if its base is broad, the mass must be chiseled away The latter procedure will be facilitated if the line of chiseling is made in the adjacent normal bone rather than through the dense tumor tissue Occasionally, the osteoma will be found to have perforated the posterior wall of the sinus or to have invaded the orbital cavity Under such circumstances, it may be necessary, in order to free the mass, to remove the posterior wall of the sinus or the roof of the orbit together with the tumor After the

excision of the tumor, the mucous membrane lining the sinus is curetted, and if there is no evidence of sinus infection and hemostasis has been complete, the osteoperiosteal flap is sutured back into place without drainage.

Should the osteoma be located in the *orbital cavity*, the eyeball is carefully retracted and an incision made over the site of the tumor and carried down to the periosteum, which is separated from the bone by blunt dissection until the mass is exposed. In case the size of the tumor is so great as to prohibit its removal through the orbital cavity, more space can be obtained if the outer orbital wall is fractured and a flap turned back as advocated by Kroenlein (133) The osteoma may then be chiseled off without difficulty After complete hemostasis, the wound is closed in the usual manner

Tumors situated in the vicinity of the *external acoustic meatus* have a tendency to occlude the canal, to interfere with hearing and, in the event of otitis media, to obstruct drainage and cause the spread of infection With the auricle drawn forward, an incision is made in the retro-auricular angle. The cartilaginous meatus is detached from the bone, care being taken to avoid injury to the tympanic membrane. The mass is then removed either with a dental burr or a chisel and mallet. The soft parts are replaced, and a dressing is applied.

Malignant Tumors

Carcinoma of the skull is usually secondary to carcinoma of the prostate, kidney, or thyroid gland, and, under ordinary circumstances, is not amenable to surgery Sarcoma, however, is more apt to be primary, and the tumor can often be successfully removed, provided it is small and its limits are well defined. The chief difficulty lies in the control of bleeding Because of the great vascularity of all sarcomatous tissues, hemorrhage is frequently so profuse as to demand prompt termination of the operation, the removal of the tumor being necessarily postponed to a later date. An added danger is the possibility of infection, owing to the tendency of these growths to break through the overlying scalp

If operation is decided upon, the tumor is exposed by turning down a flap of scalp If the growth has broken through the skin or is adherent to it, the soft tissues are removed with the tumor en masse. The section of bone to be removed is outlined by means of a series of drill holes made well beyond the limits of the mass. These holes are connected by saw-cuts, and the tumor, together with a rim of healthy bone, is lifted out in one piece Finally, the scalp flap is replaced, or, if the skin has necessarily been sacrificed, the defect is covered with sliding flaps from the contiguous scalp Since there will be considerable postoperative oozing, drainage must be instituted. The operation is supplemented by Roentgen irradiation therapy

PLASTIC REPAIR OF CRANIAL DEFECTS

Reconstruction of Scalp

The mobility and abundant blood supply of the scalp makes possible the closure of comparatively large defects without the addition of new tissue. The procedure is carried out in stages. The scalp contiguous to the lesion is undermined and mobilized, and the margins are drawn together under slight tension by means of mattress-sutures. Several weeks are then allowed to elapse to permit of the stretching of the scalp, where-

upon the process is repeated After two or three such operations direct approximation of the wound margins can usually be effected without undue tension (191) (fig 232).

A loss of tissue too extensive to be repaired in this manner may be covered with a graft or flap Since the skull offers a firm base for a pressure dressing, grafts "take" well in this locality, provided the bed furnishes sufficient vascularity for their nourishment Thin razor grafts are seldom used, as they are unstable and tend to ulcerate Split-skin and full thickness grafts are the ones most commonly chosen, since they furnish a soft pliable cover They may be taken from the thigh, abdomen, or pubes Those from the latter region are particularly suitable in that they are hair-bearing, although this feature cannot always be relied upon, since frequently the hair fails to grow in its new bed, even though the graft itself "takes" well (25) When grafts are used for the replacement of skin losses of the frontal scalp, special care must be taken that they are cut of the proper thickness, otherwise, the grafted area will be unduly depressed or elevated and will stand out as a conspicuous deformity

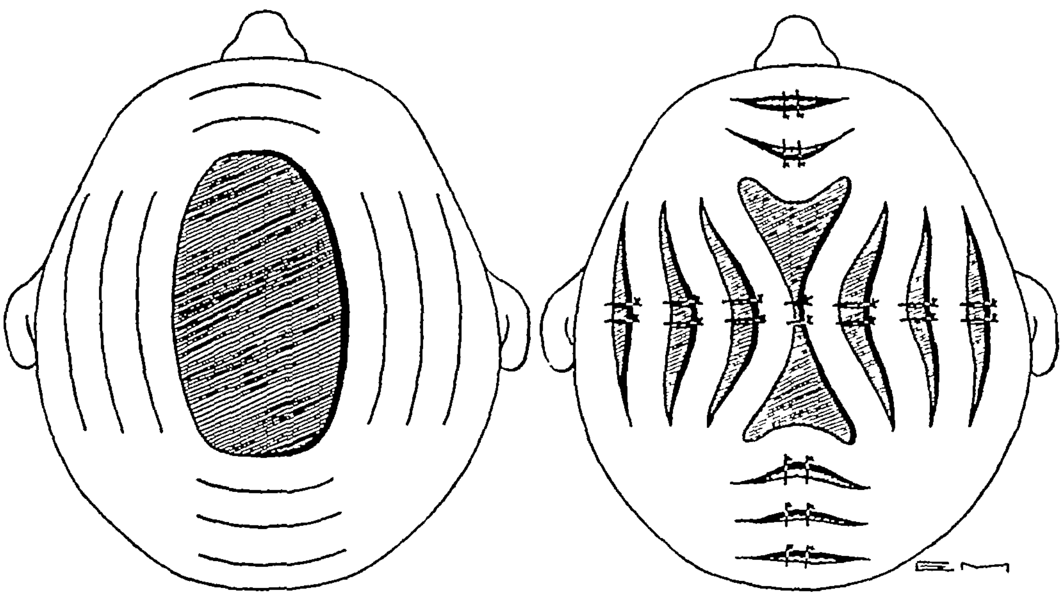

FIG 232 Mitchell's method of closing large scalp wound by multiple relaxation incisions

If the cranial bones are denuded or covered only with pericranium, grafts applied to the region are likely to fail, as such a base is unable to furnish sufficient nutrition to sustain them In such cases the outer plate should first be perforated by a series of drill holes 1 to 2 cm apart and just deep enough to penetrate the diploe (fig 233) In a week or 10 days granulations from the diploe will appear on the surface These coalesce and usually furnish an adequate nutritive bed The technic for the application of the graft is discussed in detail on page 144

A loss of scalp tissue may also be replaced with flaps taken either from the adjoining scalp or from a distance The former invariably "take," because of their abundant blood supply, and for obvious reasons they are especially indicated when the defect is limited to the anterior part of the hairy scalp (fig 234) Flaps from a distance are rarely required, since the defect can more easily be covered with skin grafts, but should the reconstruction demand such a flap, they are best taken from the acromiothoracic region or from the abdomen and brought to the scalp by means of an intermediate carrier The technic is described in Chapter II.

Alopecia

The correction of alopecia has challenged the interest of physicians of all times In the Smith and Ebers Papyri and in the writings of Hippocrates the subject is discussed in more or less detail, while in modern literature its many phases have been described so frequently that any extended review would seem superfluous. Briefly, the exact cause of the condition is unknown. It is either hereditary or acquired. The acquired type may be (1) symptomatic of acute infections, chronic nutritional diseases, endocrine disturbances, intoxications, skin diseases, etc., or (2) traumatic, following cicatricial changes due to wounds, burns, and irradiation treatment of the scalp It has been suggested that the constant friction and compression of the local blood supply caused by the wearing of a hat may interfere with the growth of the hair, and this theory has been offered as an explanation for its more common occurrence in men.

The favorite site of non traumatic alopecia is the frontal and upper parietal region. Schein (226) (1909) explains this peculiarity on a physiologic basis. He points out

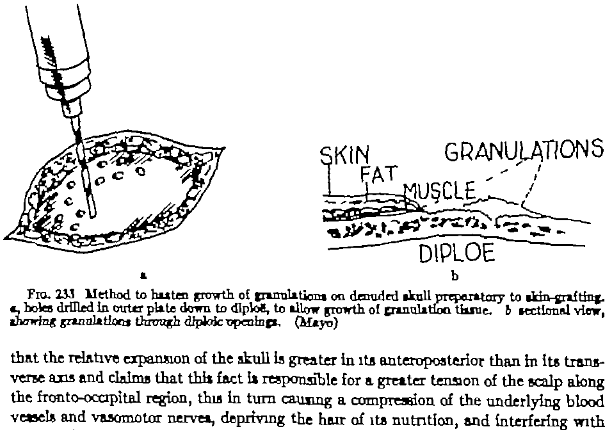

FIG. 233 Method to hasten growth of granulations on denuded skull preparatory to skin-grafting. *a*, holes drilled in outer plate down to diploë, to allow growth of granulation tissue. *b* sectional view, *showing granulations through diploic openings.* (Mayo)

that the relative expansion of the skull is greater in its anteroposterior than in its transverse axis and claims that this fact is responsible for a greater tension of the scalp along the fronto-occipital region, this in turn causing a compression of the underlying blood vessels and vasomotor nerves, depriving the hair of its nutrition, and interfering with its growth.

Treatment The logical treatment of alopecia should obviously begin with the removal of the cause, and since this is primarily a medical problem, it will not be discussed in these pages. When such treatment, however, has been tried without success, or when there has been an unquestionable destruction of the hair bearing scalp, as in the case of cicatricial degeneration following wounds and burns, other methods must be resorted to Although the defect can easily be camouflaged artificially and surgery is rarely necessary, there are cases in which it is indicated—*for instance*, in alopecia following trauma, especially when the resultant scar is unstable and subject to frequent ulcerations. Under these conditions its removal will afford the opportunity for a

resurfacing of the area with hair-bearing skin On rare occasions the occupation or psychic state of the patient justifies such a procedure even in the absence of a scar

If the defect lies on the anterior part of the scalp, a hair-bearing flap from the contiguous posterior uninvolved scalp may be shifted over it (fig 234-a) The bed having been prepared, a flap in the form of a visor with its pedicles just above the auricles is raised, shifted forward, and sutured to the anterior margin of the defect The raw area remaining is immediately covered with a split-skin graft The advantage of this procedure lies in the fact that the anterior part of the scalp is covered with hair which, if allowed to grow long, can be combed backward to cover the secondary defect Tillmanns (242) suggested turning into the defect 3 or 4 ribbons of scalp taken from the sides and suturing the free ends together in such a manner that the result resembles a wheel, with its spokes running inward from the rim and united at the hub (fig. 234-b).

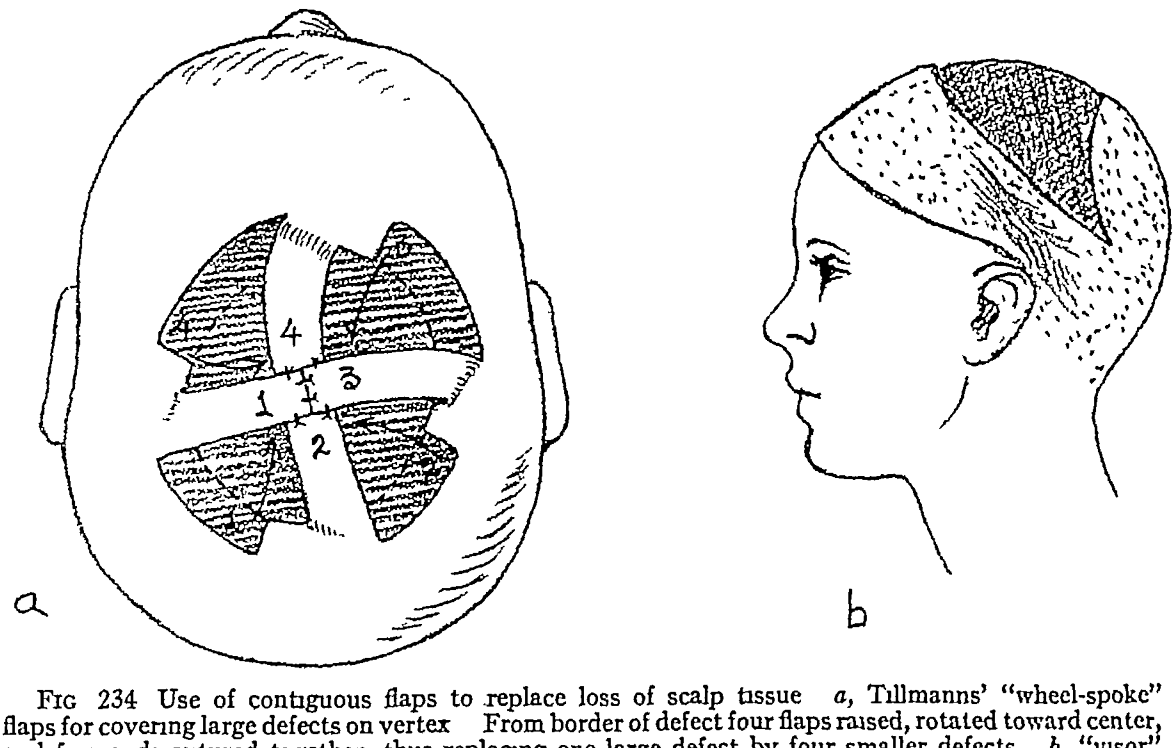

FIG 234 Use of contiguous flaps to replace loss of scalp tissue *a*, Tillmanns' "wheel-spoke" flaps for covering large defects on vertex From border of defect four flaps raised, rotated toward center, and free ends sutured together, thus replacing one large defect by four smaller defects *b*, "visor" scalp flap shifted forward to cover loss of anterior part of hairy scalp Secondary defect skin-grafted

In cases of alopecia involving principally the vertex, Passot (196) transfers to the affected area a pedunculated flap taken from the lateral region of the skull His technic follows (fig. 235-I): Under local anesthesia a flap about 3 cm wide, pedicled on the occiput, is outlined on the lateral margin of the skull The flap is shifted to the midline and implanted into an area previously prepared for its reception The secondary defect is then closed by direct approximation or grafted with the skin removed from the recipient area After an interval of 3 to 6 weeks, when the flap will have become established in its new location, the operation is repeated on the opposite side, the two flaps being made to meet in the midline of the scalp When the alopecia is limited principally to the anterior part of the scalp, Passot (196) uses a flap pedicled on the temporal artery (fig. 235-II) Should the hair be insufficient to cover the scar completely, he supplements the procedure by tattooing

Hair-bearing grafts transferred from the pubes to the scalp have often been em-

ployed, with varying degrees of success. While these grafts "take" well and not infrequently produce a luxuriant growth of hair, more often the hair falls out, and the scar which remains serves only to exaggerate the deformity

Attempts have been made to stimulate the growth of hair by means of a subcutaneous division of the galea and epicranius muscle, on the assumption that the loss of hair is occasioned by an increased tension of the scalp in the fronto-occipital diameter The procedure is as follows An incision 2 to 3 cm. long is made in the parietal scalp and through this the scalp is undermined. A transverse incision is made subcutaneously through the galea and epicranius muscle. The small incision which served as an approach to these structures is closed with 1 or 2 silkworm-gut sutures. The resultant scar will be concealed in the hair Another suggestion for the relief of scalp tension is the advancing of the epicranius muscle An incision is made in the occipital scalp

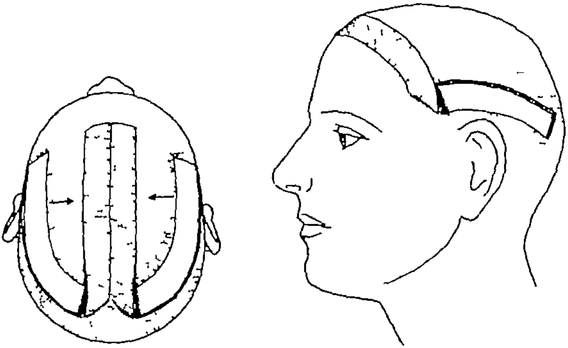

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FIG. 235 Passot's method of transplanting flaps of hairy scalp for relief of alopecia. *I*, for defects involving vertex, two flaps, raised from lateral region of skull and pedicled on occiput, shifted to midline. *II* for defects on anterior part of scalp, flaps pedicled on temporal artery rotated upward. For details, see text.

at the margin of the hair line, and through this the epicranius muscle is separated from its occipital attachment and shifted upward. Further relaxation can be obtained by undermining and advancing the adjacent skin of the neck. Recently, sympathectomy has been recommended in the hope that it may increase the blood supply of the scalp by paralyzing the vasoconstrictors (5) While procedures designed to stimulate the growth of hair open fascinating fields of investigation, the results as yet have been too meager to warrant a definite opinion as to their efficacy

Reconstruction of Cranium

A loss of skull substance may result from a compound fracture in which the fragments are so contaminated as to preclude the advisability of their cleansing and subsequent

use. Less frequently such losses are occasioned by the removal of cranial tumors, or result from necrosis following cranial osteomyelitis

In cranial losses unassociated with pathologic changes in the pachymeninx or cortex, and when the brain is amply protected by the scalp, the mere replacement of cranial covering is of secondary importance. The decision to operate in such cases must be governed by the size of the defect, its location, and the patient's reaction to the loss Generally speaking, small defects should be left untreated, large defects require closure to protect the brain from external violence; losses in the frontal region, even though small, often demand replacement for cosmetic reasons, and finally, operation is indicated in the case of patients who suffer from a feeling of insecurity arising from fear of injury to the unprotected brain

In case the bone deficiency is associated with damage to the underlying pachymeninx and cortex, as is usually the case, its *repair often becomes a primary consideration* Here the cranial loss permits the scalp to become adherent to the subjacent pachymeninx and brain, and the subsequent cicatrization results in distortion and irritation of these structures, giving rise to a characteristic train of manifestations referred to as the "trephine syndrome" The patient complains of a sense of emptiness on the side of the lesion and of frequent attacks of nausea, vertigo, headache, and emotional disturbances. His discomfort is increased when he leans over, exerts himself unduly, or is subjected to external jolting, such as is occasioned by riding in an automobile. Epileptic seizures supervening several months after the injury are not uncommon sequelae, and are said to occur in 10 per cent of all cases of trephined skull wounds Examination of the cranium reveals a depression over the site of the defect, which may or may not pulsate and which bulges with every exertion on the part of the patient In such cases the removal of the scar from the pachymeninx and brain and the replacement of the lost bone will often effectually relieve most of these symptoms, although clinical experience indicates that epilepsy and organic brain lesions which have already become established are not materially affected by such treatment.

Cranial repair should be undertaken only after the initial wound has completely healed and at least 6 months have elapsed after the subsidence of the last sign of infection. Operation before this time may activate a dormant focus Before a plastic closure is decided upon, neurologic and roentgenographic examinations are essential Should such an investigation show evidence of increased intracranial pressure, meningeal irritation, granulating cerebral hernia, or the presence of a foreign body in the brain substance, operative intervention is for the time being contraindicated

Prior to operation the head is prepared and draped in the customary manner Anesthesia is secured by local infiltration of the scalp with procain epinephrin Provision against hemorrhage is made by recourse to one of the methods outlined on page 549

Exposure of Defect and Preparation of Bed

A scalp flap is outlined over the site of the defect by an incision running parallel to the blood vessels Since the flap materially assists in furnishing nutrition to the graft, every provision must be made that it be supple and well nourished. It should contain a minimum of scar tissue, since such tissue predisposes to ulceration and suppuration of the flap, and this may spread to the transplant. If a horseshoe-shaped cicatrix

already exists as a result of a previous trephine operation, the flap should be so planned as to be outlined by the excised cicatrix Should a linear scar be present, the flap is cut in such a way that the scar will run parallel to it (fig 236) When the scalp over the affected area shows an irregular, thin, unstable scar, it is best to excise it, close the wound by plastic readjustment of the contiguous tissue (p 581), and postpone attention to the underlying structures until complete healing has taken place

The size of the proposed flap will obviously depend upon the extent of the skull defect and the source of the transplant. If the latter is to be procured from the outer plate of the skull contiguous to the defect, the flap will necessarily have to be cut large enough to cover both donor and recipient areas. In any event, it should be of such

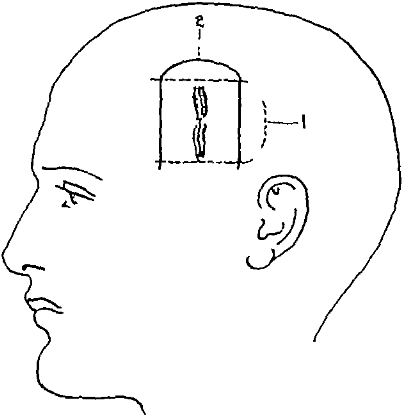


FIG 236 Outline of scalp flap 1 incorrect incision, with flap cut across blood supply and vertical scar obstructing its nutrition. 2 correct incision with flap following course of blood supply, and scar lying parallel to direction of flap interference with nutrition being thus minimized. (Kirschner)

dimensions that the suture line of the flap will not overlie or coincide with the margins of the underlying graft.

In the separation of the scalp flap at the points where it comes in contact with the pachymeninx care must be taken not to perforate the membrane. Because of the close adhesion between these structures such an accident will often be found difficult to avoid but it can usually be prevented if the plane of dissection is kept above the level of the scar, and if the removal of the cicatrix from the pachymeninx is postponed until after the scalp flap has been turned down A small perforation, however, with the escape of a little cerebrospinal fluid is no cause for alarm

After the scalp flap has been turned down, it is not always easy to define the bone defect, because of the extension of periosteum over its margins and into the pachymeninx. Removal of the scar is best begun by making a circumferential incision in

the pericranium 2 to 3 mm outside of the scar border The pericranium and cicatrix are then raised en masse with a periosteal elevator With the bony margins thus exposed, the adherent pachymeninx is separated from the under surface of the cranial defect for a distance of 5 to 6 mm in all directions, until the margin of the bone loss is completely bared. An indication that the pachymeninx has been properly detached will be the falling back of the dural cicatrix into the cranial cavity and the reappearance of cerebral pulsations The dural scar thus freed is then excised, a layer of sufficient thickness being left over the brain to function as pachymeninx (fig 237) With a bone-cutting forceps the margins of the bony defect are then excised and freshened for a distance of 1 cm beyond the scar on the pachymeninx, in order to expose the membrane for examination

If the pachymeninx is found to be deficient, it is repaired in the manner described on page 598 Should it be found undamaged, a bed is prepared in the bone for the reception of a transplant With a chisel the margins of the bony defect are beveled inward for a distance of 1 5 cm This beveling will prevent sinking of the transplant into the skull opening and will also insure a broad area of contact between the graft

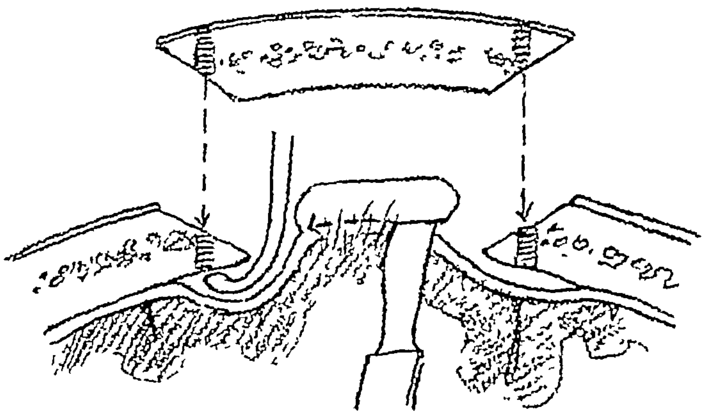


FIG 237 Closure of cranial defect Dura separated from under surface of bone Scar excised, layer of sufficient thickness being left to function as pachymeninx Margins of bony defect beveled inward for distance of 1 5 cm Shape of graft and drill holes for immobilization indicated

and its bed. Wilson (256) creates a shelf for the graft by removing, with an electrically driven burr, the outer table of the skull for a distance of about 1 cm. all around the opening

Provision for immobilization of the transplant may be made by drilling 4 holes at equal distances from each other along the margin of the bone. A model of the defect is made (p 146) to serve as a pattern by which to fashion the graft. When hemostasis has been secured, the wound in the skull is temporarily packed with gauze moistened in normal salt solution, and the flap is replaced and covered with a sterile towel until the transplant has been procured and is ready for introduction

The Transplant

The problem here presented is to secure a transplant which will adequately cover the defect, protect the brain, and at the same time exert no pressure upon it nor interfere with its mobility. Various heteroplastic substances, such as silver, gold, aluminum, celluloid, shell, ivory, animal bone, and bones from cadavers, have been employed for

the repair of the deficient bone The advantages claimed for such foreign bodies are that they can be obtained in any size, can be molded without difficulty to suit the particular need, can be easily sterilized, afford a smooth surface for the pachymeninx below and the scalp above, and in time become incorporated in a dense web of fibrous tissue. However, while the immediate results of their use may be good, unfortunately, like all foreign bodies introduced into the tissues, these implants tend to be absorbed or expelled, become buckled, or suppurate, and the fibrosis which they occasion may irritate the brain and give rise to persistent postoperative headache and other neurologic manifestations.

With the success obtainable today with autoplastic bone and cartilage grafts, there would seem to be no need for recourse to heteroplastic substances And yet, it must be stated that some surgeons of wide experience still employ foreign bodies for the correction of such defects and feel that they offer the best solution of the problem Pringle (207) advocates the use of celluloid, and others prefer metal plates. If the latter are used they are made to conform to the shape of the skull and just thick enough to furnish protection for the brain. They are perforated to reduce their weight, allow the escape of blood, and permit of anchorage for the connective tissue strands, which are said to grow into the holes. The plates are introduced as follows A scalp flap is turned down, and the cicatricial tissue excised The periosteum around the defect is separated for a distance of 1 to 2 cm. and the metal plate is slipped underneath and secured in place by means of a latticework of catgut sutures, carried across the plate and through its perforations and anchored on the periosteum around the defect. The scalp flap is replaced and drainage provided by means of twisted silkworm-gut sutures, which are removed in 24 hours

Bone Grafts. Bone is the material of choice, especially for the replacement of extensive losses as it can be obtained in sufficient quantities to cover defects of any size and resists absorption The thickness of the transplant should equal that of the skull, and its size and shape should conform with that of the defect If possible, the graft should be obtained in one piece, as this will facilitate the operation, but when this is impossible, the use of several adjoining grafts is not objectionable provided they come in contact with one another and with the defect over broad surfaces.

(1) *Source and Technic of Removal* The transplant may be taken from the external plate of the skull, the tibia scapula, ribs, sternum or ilium, the choice depending upon the size shape, and location of the defect

If the loss is small, the outer table of the parieto-occipital region of the *skull* may be used (fig 238) The pericranium is incised and elevated for a distance of 1 to 2 cm. beyond the margin of the proposed graft. This fringe of encircling pericranium is later employed to fix the transplant in its new position With a chisel and mallet the graft is cut along the plane of the diploë, the inner table of the skull being left intact Although these transplants are advantageous in that they have the proper curvature and leave no secondary deformity in another part of the body, their removal occasions considerable trauma to the brain. Furthermore, it is almost impossible to separate the outer plate without fracturing it, although such fractures are of little consequence, provided the pericranium remains intact (90)

The *tibia* is a convenient source for such a transplant as it is readily accessible and capable of furnishing enough bone to cover comparatively large defects. If necessary, two grafts—one from each tibia—may be employed and alined against each other

The method of obtaining the transplant has been described in detail on page 171 Briefly, an arched incision 20 cm long is made along the inner surface of the tibia The flap thus outlined is reflected, and a pattern of the defect is placed on the bone and outlined with a scalpel An osteoperiosteal graft 4 to 5 mm. in thickness is cut from the bone with a fine saw or chisel The under surface of the graft is smoothed and curved by means of a series of saw-cuts, so that its contour will correspond with the convexity of the skull (184) (fig 239)

The technic for the removal of transplants from the *ribs*, *sternum*, *scapula*, and *ilium*, is described on page 173

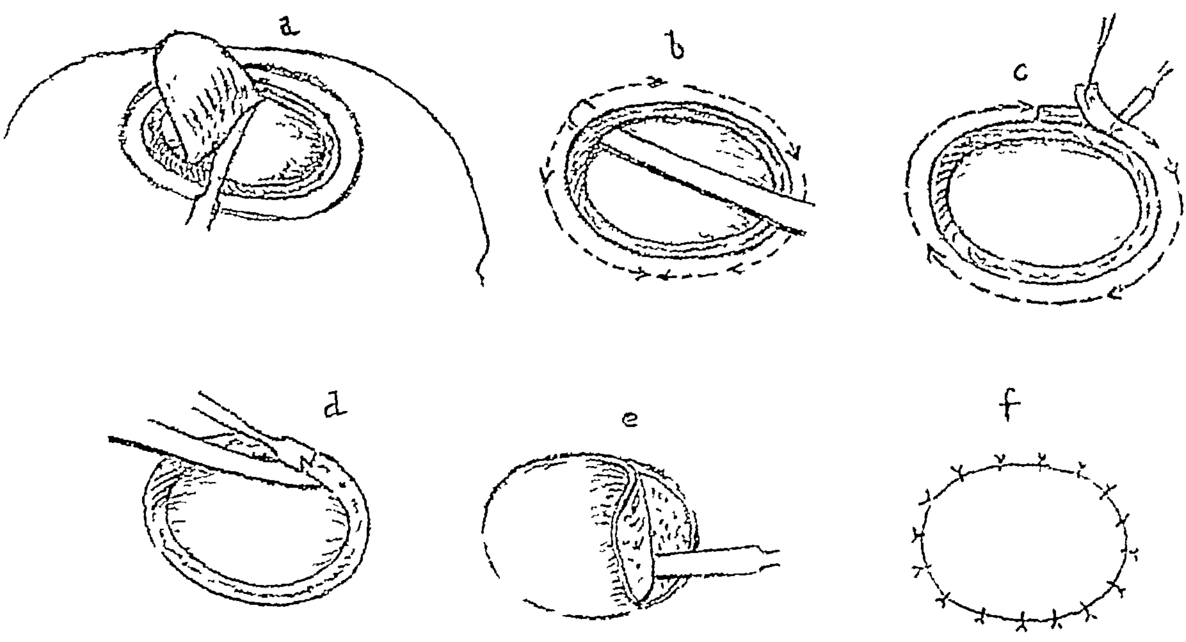
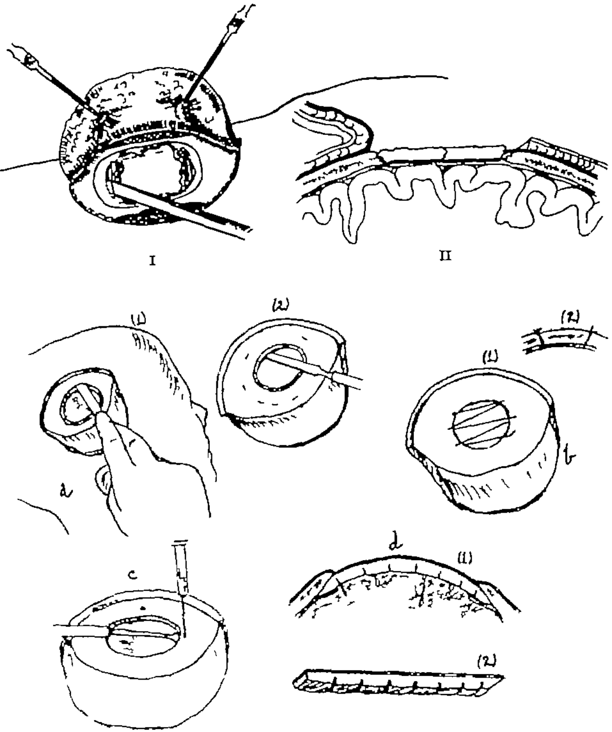


FIG 238 Repair of cranial defect with osteoperiosteal graft taken from outer plate of skull *a*, scar removed by incision following line of old scar *b*, pachymeninx freed from bony rim *c*, circumferential strip of pericranium, 6 mm wide, removed to provide for broad bony contact with graft. *d*, with dura protected, margins of bone beveled with chisel *e*, osteoperiosteal graft removed from skull to pattern in plate of diploe, with fringe of pericranium extending 1 to 2 cm beyond margins Transplant resembles thick fish scale with fragments held together by pericranium (It is not necessary that thickness of graft equal that of outer table, as osteogenesis will take place) *f*, graft molded with fingers to desired curvature, placed into defect, bony surface in, and immobilized by suturing fringe of pericranium to pericranium of defect Scalp wound closed in layers Rubber drain inserted for 24 hours (Coleman)

(2) *Transfer of Graft* After the bone graft has been removed, it is trimmed and transferred immediately to the prepared site (fig 239). The smooth periosteal surface is placed against the pachymeninx in order to protect it against friction and prevent an inward exostosis which might occur in the absence of this limiting membrane The outer raw side of the transplant is covered with a flap of pericranium taken from the bone adjacent to the defect Lexer (143) suggests that if there is no available periosteum in the neighborhood, the graft be introduced with its periosteal surface outward

(3) *Immobilization and Closure.* The graft can be immobilized in one of many ways (fig 239). It may be slipped beneath a pocket of pericranium, morticed between the inner and outer cranial plates, chromic catgut may be threaded through drill holes previously made in the bone and in the graft; or it may be held in place by a latticework of sutures passed across the graft and anchored to the marginal periosteum



III

Fig. 239 Repair of cranial defect with osteoperiosteal graft from tibia. *I* procuring of graft. Flap over tibia reflected. Pattern of defect placed on bone and outlined on periosteum. Osteoperiosteal graft 4 to 5 mm. thick cut from tibia with chisel. *II*, smooth periosteal surface placed against pachymeninx, to prevent inward exostosis. Outer raw surface covered with flap of pericranium taken from bone adjacent to defect. (Kirschner) *III*, preparation of bed and immobilization of graft. *a1*, scalp flap turned down scar removed, and pericranium elevated from outer surface of defect. *2*, pachymeninx separated from under surface of bone to dotted line with dull elevator *b* graft in place and immobilized by latticework of sutures passed across it and anchored to margin of periosteum. *c* graft immobilized by carrying sutures through drill holes previously made in bone and graft. *d1* graft immobilized by tucking it between inner table of skull and pachymeninx. *2* method of curving graft by saw-cuts on under surface.

Nesselrode (185) tucks the edges of the graft in between the inner table of the skull and the pachymeninx After the transplant has been immobilized, it is overlaid with the previously reflected pericranium. The scalp flap is then sutured back in place with interrupted sutures of silk Since complete hemostasis is difficult to secure, and, in the absence of drainage, hematomata are likely to collect, a small silkworm-gut drain is introduced into the dependent margin of the wound Finally, a firm headcap pressure dressing is applied The drain is removed after 24 hours and the skin sutures on the tenth day The postoperative treatment includes rest in bed for 2 to 3 weeks

Cartilage Grafts. Cartilage was first used for the correction of skull defects by Morestin (166) in 1915 This material has many desirable qualities, it can easily be modeled into any desired shape, it forms a fibrous union with the margins of the defect, affording a protective covering almost as solid as the skull itself, and under aseptic conditions it resists absorption However, in the presence of infection, a sinus is likely to form and remain open until the infected cartilage has been completely expelled or removed

This type of graft is obtained from the costal cartilage of the ribs in the manner already described (p 184) Briefly, the cartilage is exposed through a vertical skin incision about 15 cm long and 5 cm from the midline, on the right side of the thorax The incision is deepened down to the rectus abdominus muscle, which is split in the direction of its fibers The muscle is retracted, and the seventh, eighth, and ninth costal cartilages are laid bare Larger grafts are obtainable by a prolongation of the incision in either direction The pattern of the defect is laid on the denuded cartilage and outlined with a knife, the incision being carried through the perichondrium. The pattern is then removed and the incision deepened into the cartilage for a distance equal to the depth of the defect With the knife held flatwise, the graft is now cut from the underlying cartilage, care being taken that the same thickness be preserved throughout The transplant should preferably be cut in one piece, but in the case of large defects this is not always possible Under such circumstances two or more segments may be employed, provided they can be so morticed into the bony defect that they will receive firm support Hemorrhage is controlled, and the costal wound is closed in three layers—muscle, aponeurosis, and skin—by the assistant, the surgeon meanwhile trimming and modeling the graft, so that it will fit accurately into its new bed The skull wound is cleared of blood-clots and thoroughly dried, and the cartilage graft is inserted, perichondrial side down. Not only will this permit a smooth surface to come in contact with the pachymeninx, but the subsequent curling of the graft on the perichondrial side will help to adapt it to the natural curve of the skull. If the defect is in the thin, squamous portion of the temporal bone, the transplant is slipped between the pachymeninx and the skull In the thic[illegible] parts of the skull the margins of the graft are morticed into the diploe

The graft is immobili[illegible] following m[illegible] 9). One end of a catgut stitch is passed through [illegible] [illegible]um and tied, is passed again through the pericranium on the [illegible] [illegible]e breach [illegible] [illegible]kward and forward in a zigzag direction, until [illegible] [illegible]red wi[illegible] [illegible] (246, 258). The scalp flap is then re[illegible] [illegible]worm [illegible] a pressure dressing applied The dra[illegible] hours. [illegible] withdrawn after 10 days

Ballin (11) uses half thickness rib grafts for the correction of skull defects, and his technic, patterned after that of Gallie and Robertson (94) and Brown (26), is as follows (fig 240)

"1 We procure the graft by exposing one or two ribs on the side of the thorax through a flap incision. We use the sixth and seventh ribs, the middle of the incision being about the midaxillary line 2 A quadrilateral piece of fascia is excised from the pectoralis fascia, somewhat larger than the skull defect to be covered. This fascia is kept in a warm saline solution. 3 The rib is exposed by pushing the muscles aside. The periosteum is incised along the upper margin of the rib, then the outer half of the rib is chiselled off, leaving the inner half intact upon the pleura. This is done by chiseling along the upper margin with a narrow, thin-bladed chisel, splitting the rib gradually for the required distance After the rib is split throughout the length of graft desired, the graft is removed by biting through each end with strong bone scissors. The splitting need not be carried down to the lower or inferior edge of the rib A very little caution will avoid entering the pleura. Grafts can be taken from two and three adjoining ribs, if necessary for covering a large skull defect. These grafts are also kept in saline solution, and the chest wound is closed in layers. 4. The skull defect is exposed by a quadrilateral flap The skin is carefully dissected from the underlying adherent brain or dura, though the minute dissection of all scar tissue from the brain, advised by some, is not deemed necessary The dura is separated from the periosteum around the edges of the defect and the edge of the bone taken away for one-quarter inch around the entire periphery, using a gnawing bone forceps or small chisel. Irregular defects are made regular in outline to receive the grafts properly The fascia transplant is next placed over the exposed brain, pushed underneath the bone edge and smoothed out. Sutures are not needed, in our opinion, to keep this fascia graft in place. 5 The bed for the reception of the bony graft is now prepared as follows On opposite sides of the defect the outer and inner tables are separated by driving the chisel lightly between the two, along the exposed edge of the diploë. With only a few strokes of the chisel a short slot is thus easily formed in the cancellous middle layer of the cranium. 6 The rib grafts are put in place by simply inserting each end in the prepared slot. If the rib is made a trifle longer than the defect it will tend to curve outward, away from the brain, and will keep its position in the slot firmly because of its elasticity Two or more grafts can be placed side by side to bridge a large defect. 7 The skin flap is turned back and sutured in place."

Compound Flaps. The transfer of bone in the form of a flap for the reconstruction of cranial defects has many advocates. While theoretically these flaps should 'take' better than free bone grafts, clinically they have proven less satisfactory They are difficult to cut in one piece, and the bone segments are apt to become detached from the flap and undergo necrosis. Furthermore, their use is limited, as they cannot be employed in children and in the aged, owing to the absence of the diploë, and for the same reason they are inapplicable in the squamous portion of the temporal bone. Moreover, the trauma inflicted upon the skull by their separation may lead to concussion

Garré Operation Garré's (95) technic is as follows (fig 241) A horseshoe-shaped scalp flap, with its pedicle in the temporal region, is turned down The flap should be sufficiently large to expose not only the defect but an equal area of uninjured skull contiguous to it. The margins of the bony defect are identified and freshened, and the scar tissue is removed in the manner already described. A flap of pericranium of similar

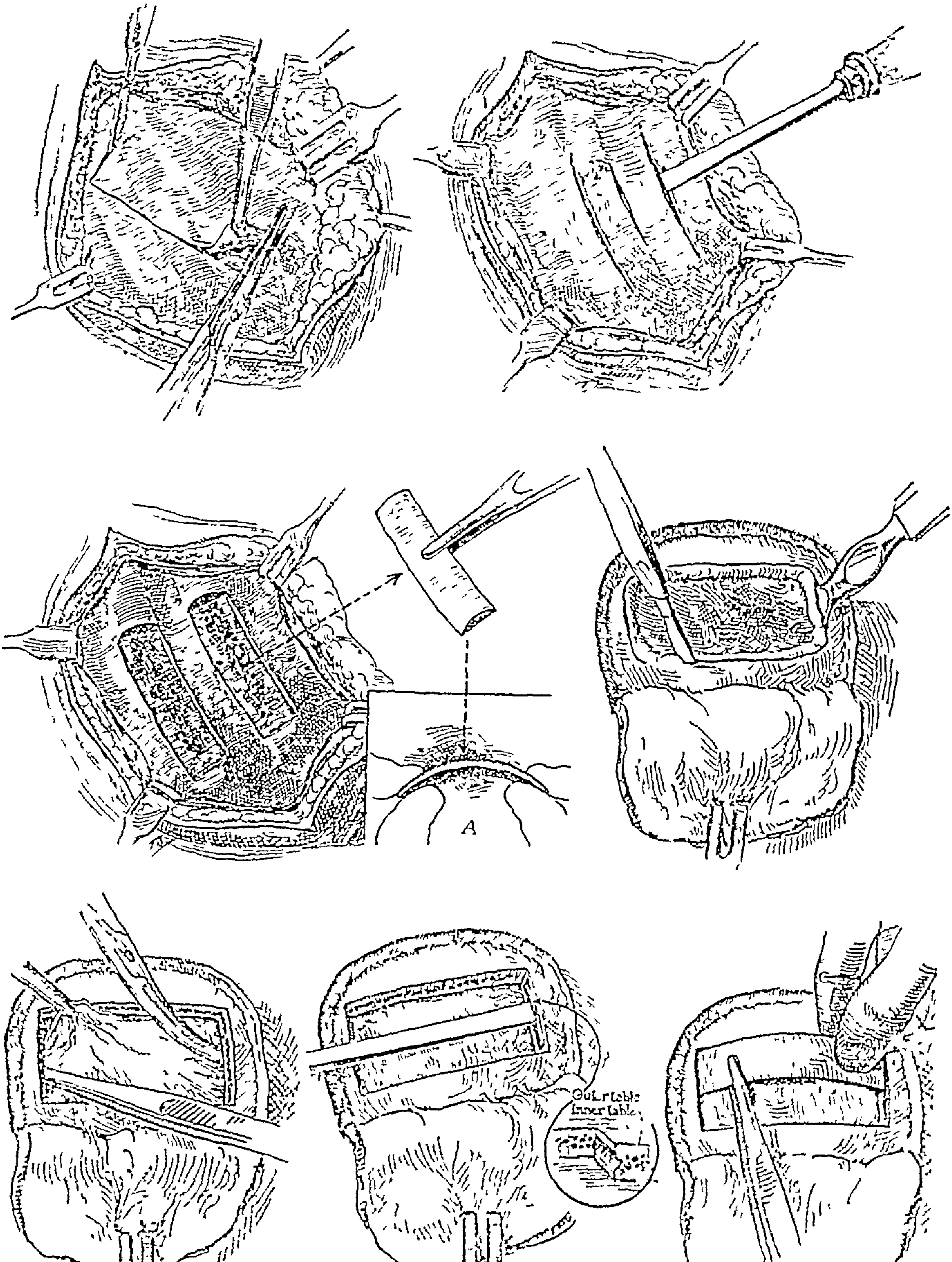


Fig 240 Ballin operation for repair of skull defect with half thickness rib cartilage graft From left to right Quadrilateral section of fascia excised from over pectoralis muscle Perichondrium incised, and outer half of rib chiseled off Graft removed Insert shows flexibility Quadrilateral flap of scalp turned down, and dural scar removed Fascia graft placed over exposed brain and tucked beneath bone Slots made in diploë for reception of graft Graft inserted in slots For details, see text. (Surg Gynec & Obst., Vol 33)

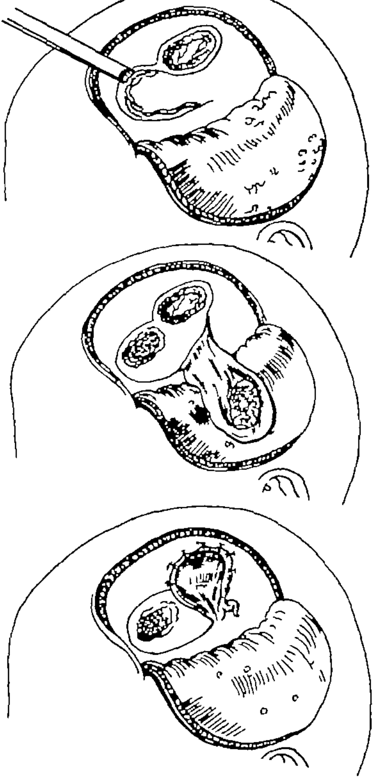


FIG. 241 Osteoperiosteal flap for repair of cranial defect. *a* horseshoe-shaped flap of scalp turned down Osteoperiosteal flap raised contiguous to defect line of separation in plane of diploë. *b* flap of periosteum, containing section of outer plate. *c* osteoperiosteal flap placed over defect and fixed in position by suturing pericranial fringe to pericranium of skull. (Garré)

shape but 1 cm larger than the defect is outlined and left attached by a pedicle in the temporal region. The periosteum is separated from the bone 1 cm. beyond the limits of the proposed transplant, and a bone graft of the required size is chiseled from the

skull with a sharp thin-bladed osteotome, the line of separation being kept strictly in the diploe Fragmentation of the bone can seldom be avoided, but this will be of no consequence, provided the individual segments remain attached to the pericranium The flap, consisting of a piece of bone exactly equal in size and shape to the defect and encircled by 1 cm of excess pericranium, is then swung into the freshened area on its pericranial pedicle The fringe of periosteum around the transplant is sutured to the pericranium surrounding the defect. Additional immobilization can be secured by splitting the margins of the bony defect and slotting the edges of the graft into them Finally, the scalp flap is sutured back in place.

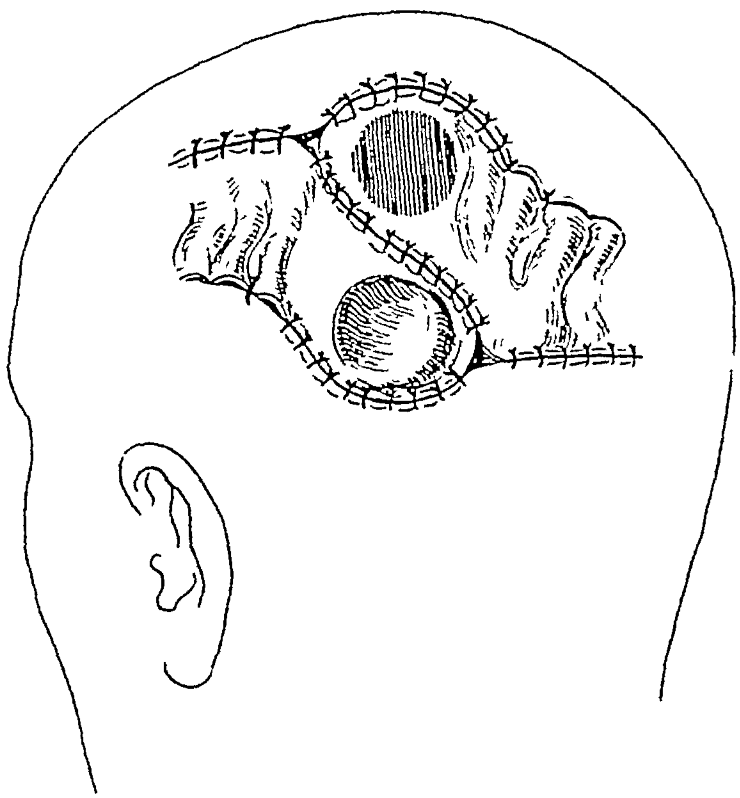


FIG 242 Reconstruction of cranial defect by transposition of flaps. Scalp flap containing chiseled-out section of outer table of skull (shaded area) and corresponding to dimensions of cranial defect swung upward to cover opening in skull Flap consisting of scalp only swung down to cover secondary defect For details, see text. (Koenig-Mueller)

The obvious disadvantage of this operation is that it brings the rough surface of the bone graft in apposition to the pachymeninx, and this fact gave rise to the von Hacker-Durante (104, 65) modification, in which the pedicle is twisted in such a manner that the periosteal surface comes to lie next to the pachymeninx The objection to the [illegible] the periosteal pedicle is interposed between the graft and [illegible] interfering with bony union In addition, the torsion [illegible] value that it might otherwise have fu[illegible]

incorporates scalp, pericranium, and a chiseled-out section of the outer table of the skull corresponding in dimensions to the cranial defect. These two flaps are transposed, so that the flap containing bone lies over the deficiency, while that consisting merely of scalp covers the secondary defect. This operation entails serious hemorrhage, and since the raw surface of the bone is laid directly on the pachymeninx, there is danger of subsequent cortical irritation. In addition, considerable buckling of the flap is inevitable, although this can be overcome to some degree by plastic excision of triangles at the corners. In the case of small defects, especially when the scalp scar requires complete removal, buckling can sometimes be prevented if the scar is excised, the mar

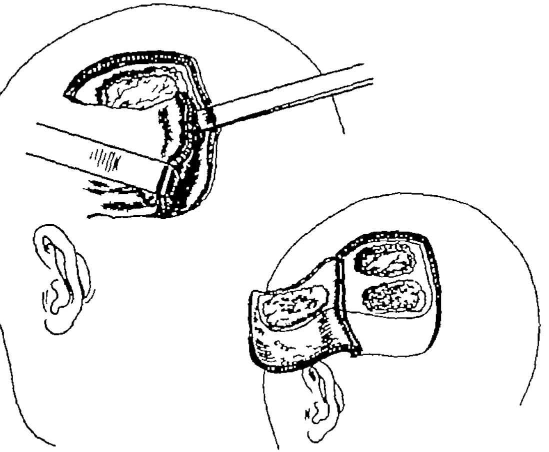


Fig 243 Osteoplastic flap for repair of cranial defect. a, cicatrix removed. b flap containing segment of outer plate of skull raised swung upward so that bone comes to lie over defect, and sutured in place. (Koenig Mueller)

gins of the defect revivified, and the osteoplastic flap slid, rather than transposed, over the defect (fig 243)

Reconstruction of Frontal Region

Defects in the frontal region demand special consideration because, unlike those in other parts of the cranium, they cannot be concealed by the hair One of the most common deformities is that following an injury in which the outer plate of the frontal bone, the anterior wall of the frontal sinus, and the root of the nose have been driven backward, leaving a deep depression in the forehead. Due to the proximity of the brain, such injuries are always serious, and early treatment is rightly centered on the

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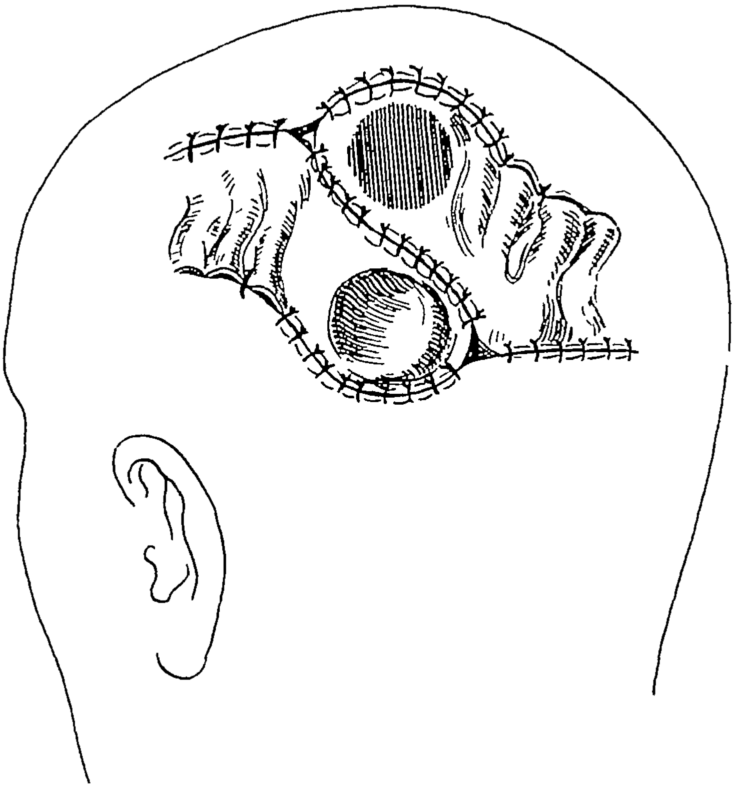

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Koenig-Mueller Operation The Koenig-Mueller (131, 176) osteoplastic flap operation consists in the transposition of two flaps after the manner of the "Z-plastic" (fig 242) Two contiguous U-shaped flaps with their pedicles pointing in opposite directions are outlined One flap is raised over the defect and comprises only scalp The other

incorporates scalp, pericranium and a chiseled-out section of the outer table of the skull corresponding in dimensions to the cranial defect. These two flaps are transposed, so that the flap containing bone lies over the deficiency, while that consisting merely of scalp covers the secondary defect. This operation entails serious hemorrhage, and since the raw surface of the bone is laid directly on the pachymeninx, there is danger of subsequent cortical irritation In addition, considerable buckling of the flap is inevitable, although this can be overcome to some degree by plastic excision of triangles at the corners. In the case of small defects, especially when the scalp scar requires complete removal, buckling can sometimes be prevented if the scar is excised, the margins of the defect revivified, and the osteoplastic flap slid rather than transposed, over the defect (fig 243)

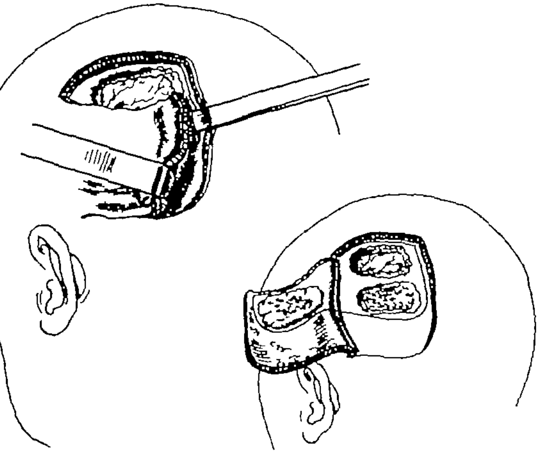

FIG 243 Osteoplastic flap for repair of cranial defect. *a*, cicatrix removed. *b* flap containing segment of outer plate of skull raised swung upward so that bone comes to lie over defect, and sutured in place (Koenig Mueller)

Reconstruction of Frontal Region

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immediate preservation of life Repositioning of the bone must therefore give place to the pressing needs of the moment, and as a result of this delay, ossification often takes place in a faulty position Another common cause of deformity in this region is the loss of bone due to disease or to surgery on the frontal sinus

Before operation on the frontal region is undertaken, a cast of the deformed part is made, both for purposes of study and as a means of gauging the size of the proposed transplant, should one be found necessary The reconstruction begins with the skin All external scars are completely excised, and if their removal leaves sufficient tissue for the approximation of the skin margins without tension, the contour of the underlying parts may be built up immediately if necessary However, if after the scar has been excised insufficient tissue remains to permit of such approximation, the overlying soft tissues must first be replaced, either by means of contiguous flaps or with tissues brought from a distant part of the body (p 204) For the building out of the contour a graft of some sort is usually necessary, but grafting procedures must not be undertaken until the soft parts have healed in completely and have been rendered pliable by massage, a process requiring several months

Obviously, the incision of approach to the defect should be as inconspicuous as possible Frequently advantage may be taken of existing scars, their excision affording a convenient avenue of entrance After the incision, the soft tissues are separated to expose the underlying bone All subcutaneous scar tissue is excised, regardless of its extent If the outer plate of the frontal sinus is depressed, an attempt is made to realine the bone in its proper position by means of a periosteal elevator If this cannot be accomplished, or if the anterior wall is missing, new tissue must be supplied Before the replacement is proceeded with, however, the sinus must be examined for evidence of infection which, if found, interdicts any grafting operation until it has cleared up

Small depressions in the contour can sometimes be filled in by the use of a contiguous flap of muscle or fat, after which the overlying skin is undermined and carefully approximated with interrupted on-end sutures of silkworm-gut or horsehair (fig 244) In more extensive deformities the contour can be reconstructed only by means of grafts of fascia, cartilage, or bone, procured and inserted as described in Chapter II For bony losses around the supra-orbital margin and angular process of the frontal bone, shaped bone or cartilage grafts must be used, the former being preferably procured from the ilium and the latter from the ribs

Reconstruction of Pachymeninx

Following a loss of the pachymeninx, as a result either of trauma or of the removal of cerebral and meningeal tumors, adhesions frequently form between the cortex of the brain and the inner plate of the skull or the scalp, the contraction of the scar causing distortion and irritation of the cerebral mass The problem in the reconstruction of these defects is to supplant the lost pachymeninx with a substitute which will not later adhere to the brain and bring about a recurrence of the original symptoms Replacement of the loss by means of foreign bodies, such as fish-skin or cellophane, prepared hernial sacs, and peritoneum, has been attempted, but only a few promising results have been reported, although De Bernardis (58) claims to have found cellophane satisfactory He asserts that after he had introduced a small sheet of this material between the brain and the pachymeninx in such a manner that it overlapped the defect

to a moderate extent, the cerebral scar remained free and unattached, soft and non irritating and did not cause cerebral distortion. The use of autoplastic material, such as fascia lata, has likewise met with disappointing results. Regardless of the

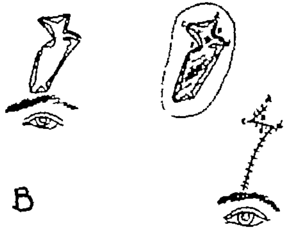

FIG 244 Reconstruction of defect in frontal region *A* defect. *B* diagram showing plan of operation Scar excised Dotted line indicates amount of undermining. Skin margins undermined and approximated *C* final result. (Medical Dept. U S Army Vol. 11)

substance employed adhesions inevitably re-form since the injury entailed by operation creates the same stimulus to scar formation as did the original trauma.

In view of the generally unsatisfactory results obtained by grafting the deficient pachymeninx is best left untreated, provided that symptoms are absent or slight and that the scalp affords adequate protection for the brain Herniation need not be feared as long as the intracranial pressure remains normal The adhesions between

the exposed brain and the overlying scalp will occasion no more discomfort than those which would eventually form between the brain and a graft In the event of serious cerebral symptoms, however, there may be no alternative to an attempt at reconstruction

Technic The defect is exposed and all scar tissue excised (p 586) If the loss is small, the margins of the pachymeninx may be safely brought together by direct approximation Bruening (27) raises a flap pedicled on the edge of the defect and composed of half the thickness of the pachymeninx, and turns it over the defect hingewise, suturing it to the opposite denuded margin (fig 245) In the case of more extensive losses a strip of fascia lata, including a layer of subcutaneous fat, is cut and placed into the bed in such a manner that the fatty surface lies in apposition to the brain. The graft should be large enough to extend 9 or 10 mm beyond the limits of the cranial loss Four anchoring catgut sutures are passed at equal distances from one another

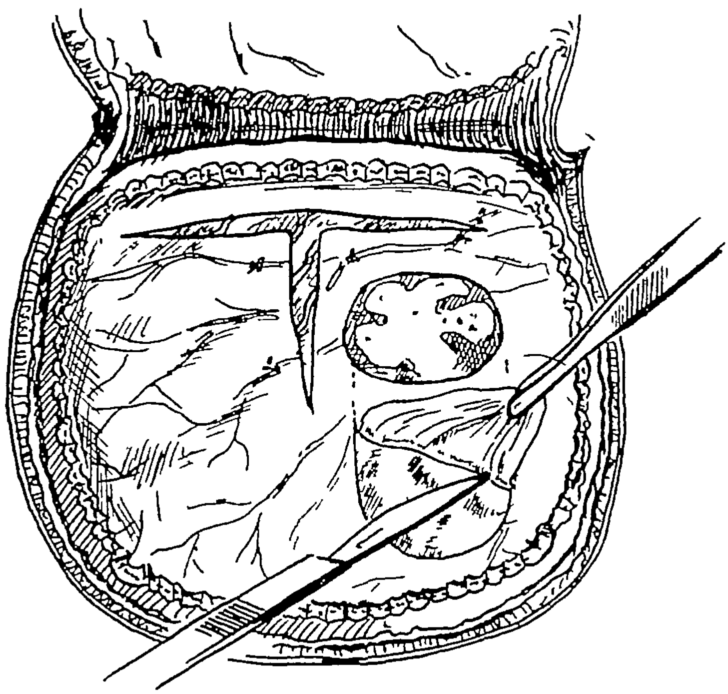

FIG 245 Repair of defect in pachymeninx by turning over half thickness of adjacent membrane hinge-fashion and suturing it to pared margins of defect (Bruening)

around the margin of the graft and are then introduced through corresponding drill holes 9 or 10 mm beyond the margin of the bony defect As the sutures are tied, the graft is automatically drawn in between the brain and the inner surface of the bone (fig 246) The balance of the graft is then tucked in beneath the bone with a dural separator, the bony defect is repaired, and the scalp wound closed

RECONSTRUCTION OF BRAIN

Following a loss of cerebral substance the contraction of the scar tissue tends to distort the brain and interfere with its function Immediately after the injury the deficiency will be masked by an edema Later, as the edema subsides, adhesions form between the brain and the margins of the cranial defect and the scalp, so that the actual loss is not evident It is only after the scar tissue around the opening has been released

that the brain can fall back into the cranial cavity and reveal the extent of the damage. The mere cutting or removal of the scar tissue mass can afford but a temporary relief, since without replacement of the lost substance cicatrization is bound to recur, perhaps to an even greater extent than before, with a correspondingly greater distortion of the brain. The lost tissue, therefore, must be replaced and the problem is to secure a substance of a weight and composition similar to that of brain tissue, and one which will heal smoothly, be non-irritating and non adherent, resist absorption, remain viable, and be procurable in sufficient quantities. Unfortunately, such an ideal substance has not as yet been discovered, and for this reason grafting operations on the brain remain unsatisfactory

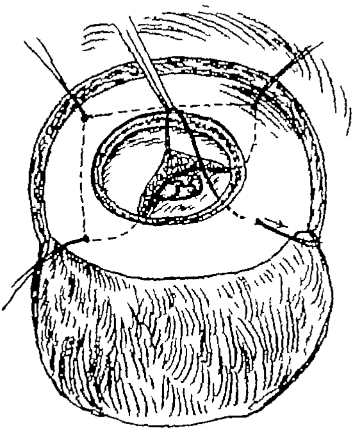

FIG 246. Closure of dural defect with fascia lata graft. Graft placed, fatty surface downward, and anchored in place by sutures passed through drill holes in skull.

The only materials which have met with even partial success are fat and fat-and-fascia. Grafts of this type will often afford temporary relief, but, as in the case of all other transplants introduced in this locality, the permanent results are disappointing Fat grafts tend to undergo absorption and atrophy and in the course of a few years are replaced to a large extent by scar tissue Fortunately however, the fat-plastic operation can be repeated if mental symptoms reappear Fat-and fascia grafts are open to the same objections, although they are said to become absorbed at a somewhat slower rate

Before the graft is introduced the cortical scar tissue must be excised, and this procedure presents a delicate problem A decision must frequently be made between complete removal of the scar tissue, with its attendant sacrifice of brain substance, and only partial removal of the cicatricial tissue, with the liability of its reappearance.

In any case, sufficient scar tissue must be excised to relieve the brain distortion and to furnish a scarless, nutritive base for the graft If the scar is found to penetrate into the sinuses or walls of the lateral ventricles, enough of the cicatricial tissue must be left to maintain the continuity of these spaces

Technic Under local anesthesia a scalp flap is turned down over the defect The margins of the bony defect are excised with a bone forceps until the brain scar is surrounded by a rim of healthy pachymeninx The edge of the scar tissue is picked up with a fine forceps and the dissection begun When feasible, the cortical scar should be excised in one piece, because in this way potentially infected foreign bodies or dormant infections lodged within the scar can be removed without liberation of the infective agent Unfortunately, removal of the scar in one piece is seldom possible, since it usually infiltrates deeply into the brain tissue If after the release of adhesions and the excision of the cortical scar the brain does not sink back into the cranial cavity, an increased intracranial pressure should be suspected, and further operation must be postponed until the cause has been determined and removed After the excision of the cicatrix a gauze tampon wrung out of salt solution is laid into the wound cavity, and the scalp flap is replaced temporarily during the preparation of the graft

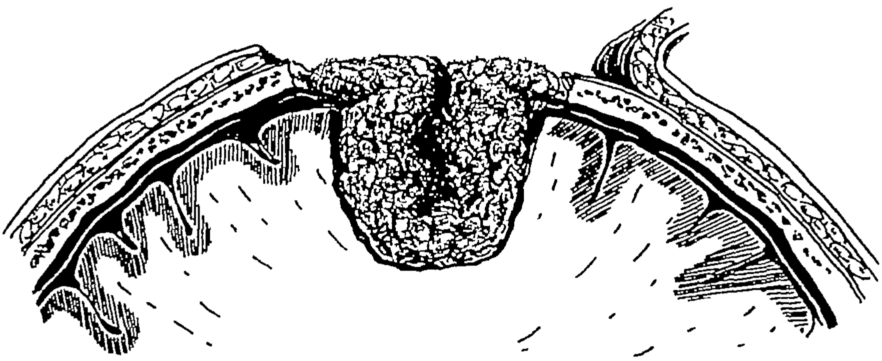

FIG 247 Fat graft to repair loss of cerebral tissue For details, see text (Kirschner)

If a fat graft is to be employed, it may be obtained from the abdomen, breast, or buttocks It should be cut from the layers immediately beneath the skin and be thick enough to fill the wound cavity completely, so as to obliterate all dead spaces After its removal it is transferred at once to the recipient bed (fig 247) Any surplus fat projecting beyond the level of the skull is removed The scalp flap is then sutured in place, a silkworm-gut drain is inserted, and a loose dressing applied The drain is removed after 48 hours Since the viability of the graft will depend largely upon an atraumatic technic, manipulation should be reduced to a minimum and the use of forceps avoided Should evidence of infection appear, it may be possible to save a part of the graft by the opening of 1 or 2 sutures and the institution of drainage, but usually it will be necessary to remove the transplant entirely, treat the infection, and repeat the operation at a later date

Repair of the cranial defect may be carried out at the same time or, better still, postponed for 3 to 6 months, until the future course of the fat graft can be determined.

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CHAPTER XI

THE NOSE

ANATOMIC CONSIDERATIONS

A knowledge of the surgical anatomy of the nose is of paramount important for a comprehensive understanding of the various nasal affections and for the interpretation of the procedures to be instituted for their elimination.

General Description

The nose is a triangular pyramid which projects anteriorly between the orbits, merging at its summit with the forehead and at its base with the upper lip (figs. 248–249).

The *root*, supported by the perpendicular plate of the ethmoid, is formed by the articulation of the nasal bones and the frontal processes of the maxillae with the frontal bone A fracture of the nasal root is especially dangerous because of its proximity to the cribriform plate of the ethmoid, the frontal sinus, and the nasolacrimal duct Fortunately, however, because of its archlike construction, its firm support, and its relative thickness, it resists considerable violence Nevertheless, when fracture does occur in this region, the great force necessary to produce it may cause the nasal bones to be driven into the nasal passages and result in a flattening of the arch and a spreading of the base (p 626)

The *dorsum* is a straight or curved ridge beginning at the nasal root and ending in the tip The upper part is supported by the nasal bones and is called the bridge of the nose, its length averaging ½ that of the entire dorsum With the glabella it forms the frontonasal angle The lower part of the dorsum is cartilaginous, composed of the anterior borders of the septal and upper lateral cartilages Toward the nasal tip the upper lateral cartilages separate for about 1 cm , presenting on palpation a small depression which, because of its structural weakness, frequently becomes the site of deformity

The free angle of the nose is formed by the graceful rounding of the medial and lateral crura of the lower lateral cartilages and is known as the *point*, *tip*, or *apex*

The *base* of the nose presents two apertures, the *nostrils* (anterior nares) lined with modified skin containing short, stiff hairs or vibrissae (fig 250) These apertures open into the nasal vestibule and are separated from each other by an anteroposterior septum, the *columella* When the tip is prominent, as in members of the white race, the transverse diameter of the base is proportionately narrow, the longest plane being in the anteroposterior or sagittal diameter The anterior nares are directed downward. This not only protects the vestibule against the introduction of foreign bodies, but also helps to warm and moisten the inspired air by raising the height of the curve and retarding the flow It is thought that the direction and shape of the nostrils bear some relation to the geographic environment of the individual Thus, inhabitants of dry,

cold climates have long noses with narrow nostrils directed downward, while those dwelling in hot climates have short noses with wide nares directed forward. In the latter instance this form and direction of the nasal apertures lowers the height of the curve and shortens the time of contact of the air with the nasal mucosa.

The *lateral surfaces* of the nose pass from the dorsum on both sides to merge into the cheek, their junction with the face forming an open angle termed the nasofacial angle. In operations about the face this is a favorite site for incisions, as it lies in a natural shadow which renders the subsequent scar inconspicuous. Below, the lateral

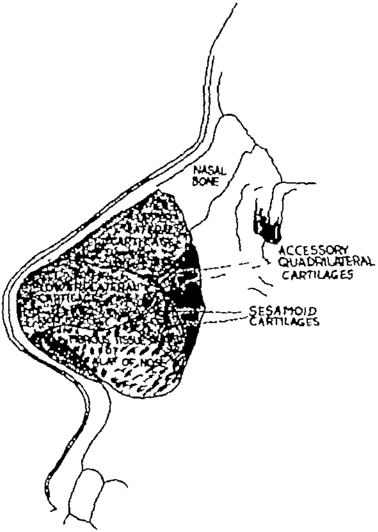

FIG. 248. Structures entering into formation of external nose.

surfaces of the nose end in rounded eminences, the alae nasi, which with the upper lip form the nasolabial sulci

The *skin* over the root of the nose and the adjacent parts is thin and loose and lends itself readily to plastic surgery Over the point and alae, however, it is thick and adherent, bound down by dense connective tissue and containing numerous sebaceous glands which frequently give rise to the formation of comedones and acne Due to the compactness of the tissues in this locality inflammatory conditions do not produce much swelling but cause great pain from pressure of the exudate on the nerves. The skin of the nose is frequently the seat of acne rosacea, lupus, rodent ulcer, and epitheli-

oma. Infections about the nose are potentially serious because of their likelihood of being carried directly into the intracranial sinuses by way of the ethmoid and ophthalmic veins (p. 978)

The *nasal mucous membrane* is thick, highly vascular, and firmly attached to the subjacent periosteum and perichondrium Because of this intimate adherence fractures

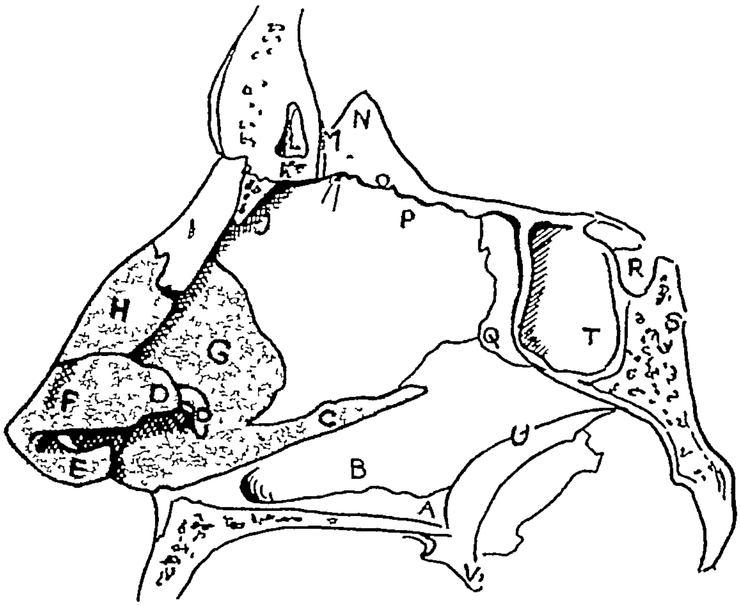

FIG 249. Sectional view of structures entering into formation of nose *A*, nasal crest, *B*, vomer, *C*, sphenoid process, *D*, lower lateral cartilage, *E*, medial crus, *F*, lateral crus, *G*, septal cartilage, *H*, upper lateral cartilage, *I*, nasal bone, *J*, articulation of nasal bone with septum, *K*, frontal bone, *L*, frontal sinus, *M*, sinus groove for ethmoidal nerve, *N*, crista galli, *O*, cribriform plate of ethmoid, *P*, perpendicular plate of ethmoid, *Q*, rostrum of sphenoid, *R*, hypophyseal fossa, *S*, clinoid process, *T*, sphenoidal sinus; *U*, choana, *V*, hamular process

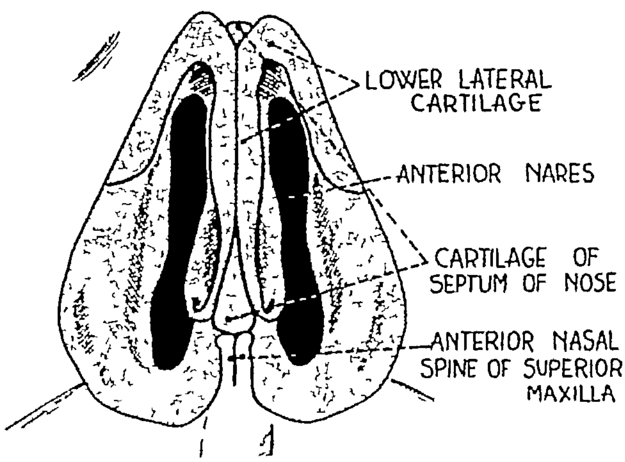

FIG 250 Structures forming base of nose

of the nose are almost invariably compound The laceration of the mucous membrane permits the entrance of air from the nasal fossae into the subcutaneous tissues, and this explains the emphysema so frequently associated with nasal fractures The mucous membrane lines all portions of the nasal fossae except the vestibular part which is covered with integument continued from the surface It is thick and vascular over the conchae (turbinates) and over the lower $\frac{2}{3}$ of the septum, while over the nasal floor and

in the space between the conchae it is much thinner, being most delicate in the para nasal sinuses. The membrane is studded with many glands which when inflamed exude a copious watery secretion It is drained by a rich submucosal venous plexus which forms over the lower conchae a group of cavernous spaces, the "erectile body," which in a turgid state may attain such a size as to obstruct the nasal cavity The pur pose of this great vascularity is presumably to raise the temperature of the inspired air

The *arterial supply* to the nose is derived from the internal and external maxillary (branches of the external carotid) and from the ophthalmic (a branch of the internal carotid) These arteries terminate in capillary plexuses which supply the nasal mucous membrane, glands, and skin.

The arteries that supply the *outer nose* are the following (1) The *lateral nasal*, distributed to the ala and the dorsum, (2) the *angular*, to the root, and (3) *irregular muscular branches*—all of which are derived from the external maxillary, (4) the *infra*

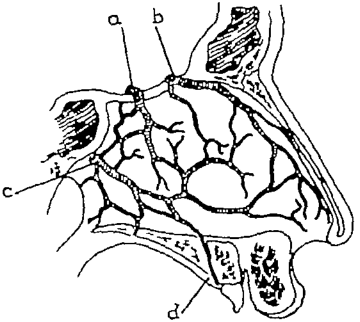

Fig 251 Arteries supplying nasal septum. *a*, posterior ethmoidal. *b* anterior ethmoidal. *c* sphenopalatine *d* anastomosing branch to anterior palatine.

orbital branches of the internal maxillary which make their appearance on the face at the infra-orbital foramen supplying the sides of the nose, where they anastomose with branches of the external maxillary (5) the *dorsalis nasi*, supplying the bridge of the nose and (6) the *supra orbital* the root and forehead—the latter two being branches of the ophthalmic. The free blood supply of the nasal skin offers a good field for rhinoplasty as it favors prompt healing and thus minimizes the danger of sloughing and conspicuous scarring

The arteries which supply the *nasal fossae* are (fig 251) (1) The *sphenopalatine* a terminal branch of the internal maxillary, which enters the nasal fossa through the sphenopalatine foramen on the lateral nasal wall, accompanied by a branch of the sphenopalatine nerve. The lateral (lateral posterior nasal) branch runs upward, down ward and forward, and supplies the mucous membrane of the nasal meati, the conchae (turbinates) the maxillary and frontal sinuses, and the ethmoidal cells. The medial (nasopalatine) branch runs transversely across the roof to the septal wall and supplies

the mucous membrane of the septum (2) The *ethmoidal arteries*, branches of the ophthalmic, which enter the nose from the orbit through the nasal slit, extend along the inner surface of the nasal bone, supplying the septum, and terminate on the dorsum of the nose after passing between the nasal bones and the upper lateral cartilages

The *veins* of the nose form a close cavernous network immediately beneath the mucous membrane They anastomose freely and terminate in the anterior facial and ophthalmic veins

The blood vessels of the nasal fossae communicate freely with those of the external nose This relationship accounts for the spread of infection to the external nose in inflammatory conditions of the nasal mucosa Because of this danger, plastic operations on the external nose should be delayed until all acute pathologic processes within have subsided

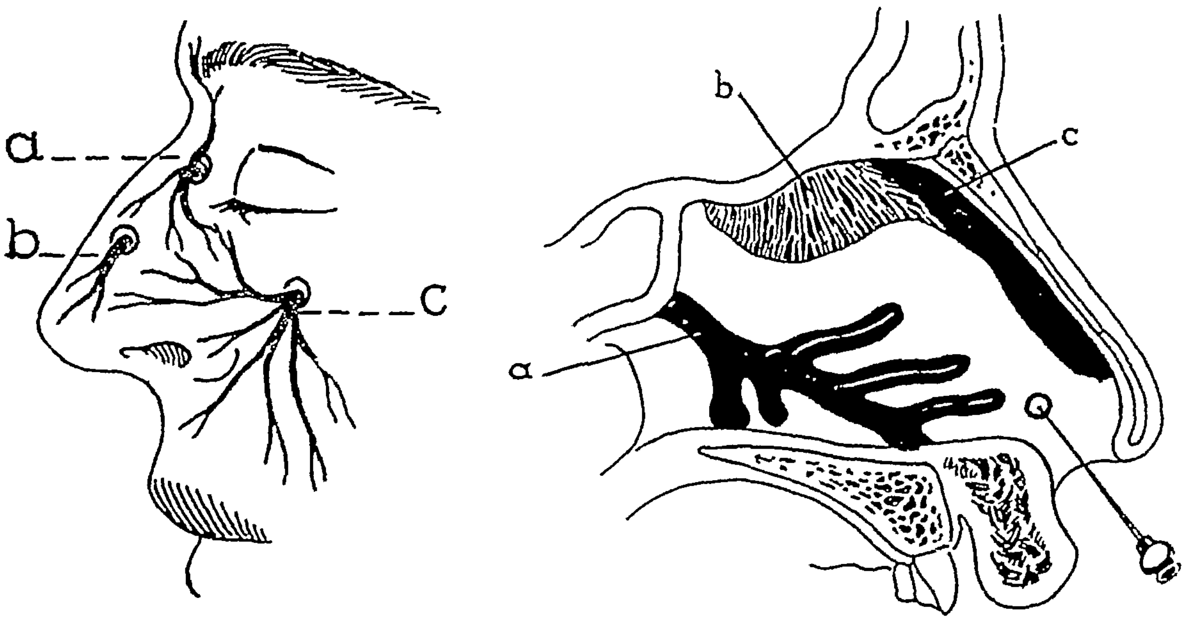

FIG 252 Nerve supply of nose *I*, external nose *a*, infratrochlear nerve *b*, external nasal *c*, infra-orbital *II*, nasal septum *a*, nasopalatine nerve *b*, olfactory *c*, anterior ethmoidal. Circles indicate points for nerve blocking (Kirschner)

The *sensory nerve supply* of the external nose is derived from (fig 252) (1) The infratrochlear, supplying the skin of the root, (2) the nasal branches of the ophthalmic, supplying the alae and the tip, and (3) the infra-orbital branch of the superior maxillary, supplying the sides The nerves which supply the medial wall of the nasal cavity are shown in Figure 252-II The only *motor nerve* to the nose is a branch of the facial which is distributed to the alar muscles

The nasal *lymphatics* are located in the connective tissue They ramify through the mucoperiosteum of the olfactory and respiratory regions and extend into the accessory sinuses The anterior groups are found between the nasal cartilages and the skin, and their collecting trunks empty into the facial and submaxillary nodes. This relationship accounts for the tendency of inflammatory conditions of the nose to give rise to submaxillary adenitis The dorsal or posterior groups of lymphatics are in the vicinity of the eustachian tubes Their coll[illegible] unks terminate in the deep cervical chain and in the retropharyngeal nodes [illegible] gement explains the occasional

occurrence of retropharyngeal abscess following nasal infections. Through the inter communications between the mucosal and cutaneous lymphatic networks infection originating in the nasal mucous membrane may spread to the skin of the nose and face

The *muscles* of the nose are vestigial Therefore, immobilization following the reduction of nasal fractures offers little difficulty, because there is no muscular pull that would tend to displace the fragments. The principal muscles of the external nose are the compressors and dilators of the nostrils and the depressors and elevators of the alae nasi In view of their insignificance only passing reference will be made to them (1) The procerus, a continuation of the epicranius, arises from the lower border of the nasal bone and is attached to the skin between the eyebrows. When functioning, it draws the inner angle of the eyebrow downward, producing a horizontal wrinkle (2) The compressor naris originates in the nasal bone and adjacent nasal cartilage near the median line, passes downward and backward to its insertion into the superior maxillary bone near the pyriform opening and into the caput angulare. Its function is to pull inward the muscle to which it is attached, producing a vertical wrinkling of the nose and a slight compression (3) The dilator naris arises from the nasal notch of the superior maxilla and is inserted into the margin of the nostril. Its function is to straighten the angle and thus enlarge the nasal aperture. (4) The caput angulare of the quadratus labii superioris originates in the frontal process of the superior maxillary bone and is inserted into the ala and orbicularis oris muscle It draws the lip and ala upward, dilates the nostril and tends to deepen the nasolabial fold. (5) The pars transversa of the nasalis arises from above the incisive fossa of the maxillary bone and is attached to the cartilage of the nose. It serves to depress the cartilaginous dorsum and to compress the ala. (6) The pars alaris of the nasalis originates in the incisive fossa and is inserted into the cartilage of the ala and into the septum It serves to draw the nostril downward and inward and to constrict the aperture. These muscles are all supplied by branches from the facial nerve.

Nasal Framework

The framework of the nose is made up of a bony and a cartilaginous portion The bony portion consists of the two nasal bones supported by the perpendicular plate of the ethmoid and by the frontal processes of the superior maxillae. The cartilaginous part comprises two upper lateral cartilages uniting with the cartilage of the septum to form a unit two independent lower lateral cartilages, and several minor accessory and sesamoid cartilages. The nasal cartilages together with their fibrous aponeuroses, enclose the pyriform opening and continue it to the anterior nares.

Bony Framework

The two *nasal bones* articulate with each other tent fashion to form the bridge of the nose Above they are narrow and strong and supported by the bony septum. Below they become thinner and wider and this relative weakness as well as their exposed position, accounts for the prevalence of fractures in this location

The upper borders of the nasal bones articulate with the frontal bone (fig 253) The lower borders give attachment to the upper lateral cartilages. The lateral borders articulate with the frontal processes of the maxillae The medial borders articulate

with each other to form the internasal suture The inner borders show crests which articulate with the perpendicular plate of the ethmoid, the septal cartilage, and the nasal spine of the frontal bone The inner surfaces of the nasal bones are concave and lined with mucous membrane, each bone presenting a groove for the nasal branch of the nasociliary nerve The outer or facial surfaces are concave above and convex below.

The frontal processes of the superior maxillae are thick triangular bony plates which extend along the sides of the nose and are joined by sutures to the frontal bone above It is upon the development of these processes and the manner in which the nasal bones are set upon them that the form and dimensions of the nose mainly depend The outer surfaces of these processes are concave, and the inner surface of each bone shows two ridges for the reception of the superior and inferior nasal conchae (turbinates)

The skeletal nasal fossae open externally on the face, forming conjointly at a level above the nares an inverted cordiform opening known as the *pyriform aperture* This opening measures 1 6 cm vertically and slightly less transversely at its widest part and

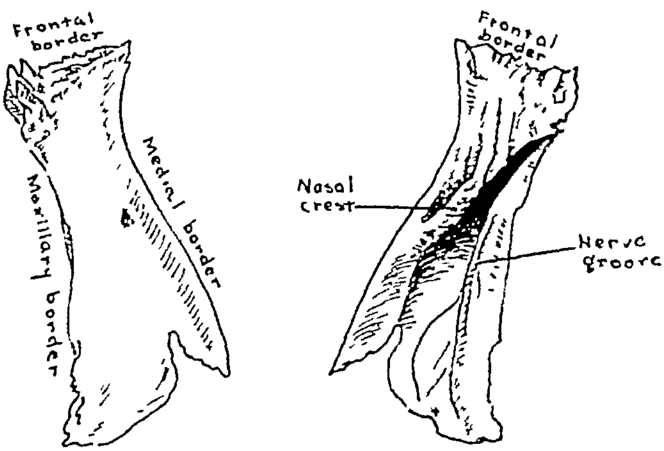

FIG 253 Outer and inner surface of nasal bones

can be palpated by a finger introduced into the nostril That portion of the nose between the pyriform opening and the anterior nares is called the vestibule The pyriform opening is bounded above by the free border of the nasal bones and elsewhere by the maxillae. Projecting from the floor of the midsagittal plane is the *nasal spine* of the superior maxillae, a thick, prominent, rough and irregular projection, about 1.8 cm long and 0 3 cm high In front it presents a sharp edge, above, it is grooved for the reception of the septal cartilage, and behind, it articulates with the vomer Undue prominence of the nasal spine may cause the upper lip to project and make it appear abnormally short Partial excision of the nasal spine is usually sufficient to correct this deformity (p 731). Complete removal should be avoided, however, since the resultant loss of support to the septal cartilage is likely to be followed by a depression of the cartilaginous dorsum. The floor of the pyriform opening is rounded and directly continuous with its sharp lateral border The opening is surgically important In the performance of a lateral osteotomy of the frontal process of the superior maxilla, the saw must be ... the outermost angle of the aperture If introduced above thi... ll remain, if placed below it, the operation will be made ... will b... to be carried through the thickest part of ... eminently explored surgically by everting

the upper lip and making a transverse incision through the mucous membrane into the soft parts which connect the lip with the upper jaw (fig 316-a)

The above description of the bony framework takes no account of variations in nasal structure, of which there are many, but the possibility of such variations should be kept in mind before any attempt is made to readjust the nasal framework. In individuals of the white race the nasal bones are relatively larger and more prominent than in those of the black and yellow races. In the process of development the nasal bones may fuse as a result of the obliteration of the internasal suture, or they may be replaced, partially or completely, by an overdevelopment of the frontal processes of the maxillae or by a medial projection of the frontal bone In rare instances, both nasal bones are absent, the perpendicular plate of the ethmoid coming to the surface between the nasal processes of the maxillae. Occasionally, the nasal bones are divided into segments or completely replaced by membrane

Cartilaginous Framework

The *upper lateral cartilages* are two flat triangular plates situated immediately below the free border of the nasal bones, spreading outward and downward from the anterior margin of the septum. They form approximately the middle third of the nose and are important elements in the maintenance of its normal shape in this location Their anterior borders are thick and directly continuous with the septal cartilage. Under trauma these cartilages may be dislocated from the septum or from the nasal bones, or one of them may be bent back upon itself When they are detached from the nasal bones, considerable pain is occasioned, owing to the associated injury of the nasal nerve which emerges between the cartilages and the bones

The *lower lateral cartilages* encircle the nostrils and assist in maintaining their patency Each cartilage consists of a medial and a lateral crus (fig 254) The two medial crura approximate each other in the medial plane and, together with their investing soft tissues, form the lower part of the nasal septum, which, owing to its free mobility, is referred to as "the movable septum." Above, the medial crura are united to the septal cartilage, posteriorly, they end in free out turned borders, anteriorly, they bend to form angles with the lateral crura, the approximation of the two angles forming the tip of the nose. The lateral crura are attached above to the upper lateral cartilages and posteriorly to the maxillae by means of fibrous tissue. The lower borders of the lateral crura fall short of the free edges of the nostrils which in this location are composed only of fatty and connective tissue (fig 248)

The lesser alar cartilages are small and variable in number and are found embedded in the fibrous tissue in the wings of the nose, between the lateral crus of the lower lateral cartilage and the maxilla. The *sesamoid cartilages* range in number from one to three and are frequently absent altogether They are usually located between the upper lateral and the septal cartilages.

The *nasal septum* is composed of cartilaginous, osseous, and mucocutaneous elements (fig 255) It constitutes the partition wall of the nasal fossae and forms the keystone of the nasal pyramid. Hence, if it is displaced, the adjacent segments of the arch follow the dislocation, and the nasal bridge becomes established on an abnormal level. Embryologically, the septum passes through three distinct stages of development. It is at first membranous later a lamina of cartilage develops in its substance, portions of

with each other to form the internasal suture The inner borders show crests which articulate with the perpendicular plate of the ethmoid, the septal cartilage, and the nasal spine of the frontal bone The inner surfaces of the nasal bones are concave and lined with mucous membrane, each bone presenting a groove for the nasal branch of the nasociliary nerve The outer or facial surfaces are concave above and convex below

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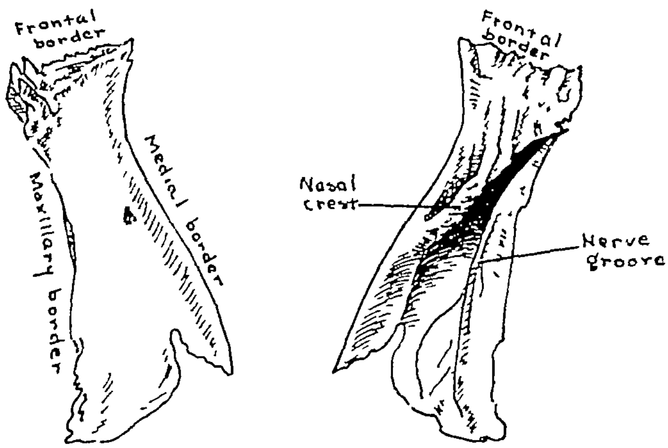

FIG 253 *Outer and inner surface of nasal bones*

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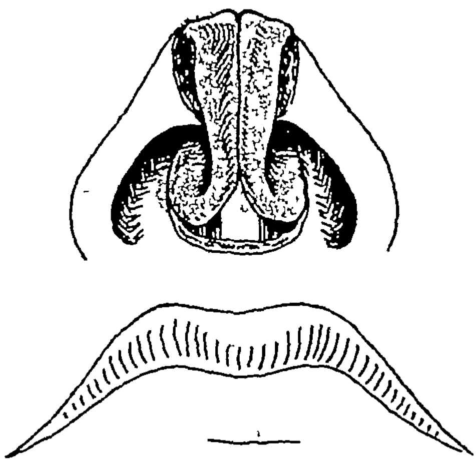
The *nasal septum* is composed of cartilaginous, osseous and mucocutaneous elements (fig 255) It constitutes the partition wall of the nasal fossae and forms the keystone of the nasal pyramid. Hence if it is displaced, the adjacent segments of the arch follow the dislocation, and the nasal bridge becomes established on an abnormal level. Embryologically, the septum passes through three distinct stages of development. It is at first membranous, later a lamina of cartilage develops in its substance, portions of

it remaining to form the septal and vomerine cartilages and the balance being gradually replaced by bone.

The *cartilaginous septum* supports that portion of the nasal dorsum below the bony arch and consists of the septal cartilage, the vomeronasal cartilage, and the medial crura of the lower lateral cartilages



[FIG 254 Medial crura of lower lateral cartilage Anteriorly, they are continuous with lateral crura, to form tip of nose Posteriorly, they end in free out-turned borders (See Figures 249 and 250)

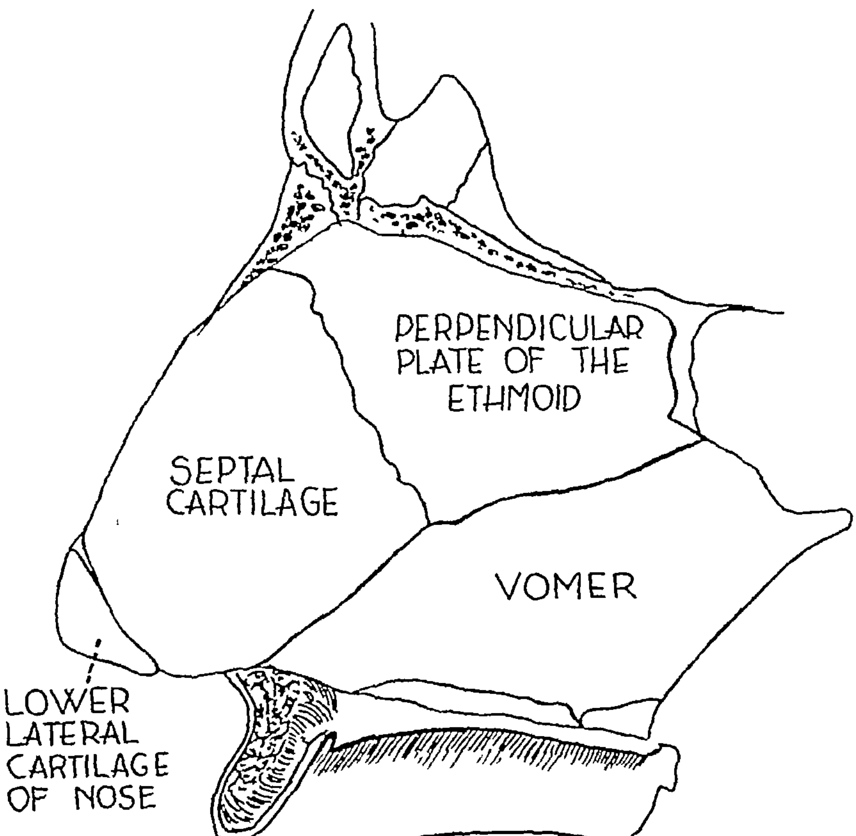


FIG 255 Structures entering into formation of nasal septum

The *septal cartilage* is quadrilateral in shape and enters into the framework of the external nose, forming the greater part of the medial partition Anteriorly the septal cartilage becomes continous with the upper lateral cartilages which diverge from it in

a winglike manner Its lower border is short and is attached by means of fibrous tissue to the medial crura of the lower lateral cartilages. Its anterior angle is rounded and falls short of reaching the apex of the nose by approximately 1 cm The anterior border is fixed along the posterior aspect of the internasal suture the posterosuperior border is attached to the perpendicular plate of the ethmoid, and the postero-inferior border is joined to the vomer and maxilla Between the vomer and perpendicular plate of the ethmoid the cartilage forms a projection called the 'sphenoidal process of the septal cartilage.' This projection may extend as far as the sphenoid bone, especially in children. The septal cartilage is involved in almost every nasal disfigurement. Being a flexible body, it yields easily to pressure and may be dislocated from any or all of its attachments. If it is dislodged or bent, or for any reason fails to exercise its function of support, the surrounding areas become a party to the displacement In the developmental period the septal cartilage and the vomer play an important part in the raising of the dorsum. When these structures are destroyed in early life, the infantile stubby flattened nose results.

The *vomeronasal cartilages* are two narrow strips about 10 mm. in length Posteriorly they are attached to the vomer and to the maxilla, and anteriorly to the septal cartilages. They reach their maximum development in the embryo During the eighth week of fetal life a chondrification center appears on either side of the septum, the two plates uniting to form the vomerine cartilages, but only that part which aids in the formation of the septum persists in adult life

The *osseous septum* comprises the perpendicular plate of the ethmoid, the vomer, the frontal spine of the frontal bone, the rostrum of the sphenoid, and the crests of the nasal, maxillary, and palatal bones (fig 249)

The *perpendicular plate of the ethmoid* forms the upper third of the septum and articulates anteriorly with the nasal spine of the frontal bone and with the nasal bones, anteriorly and inferiorly with the septal cartilage and vomer, and posteriorly with the crest of the sphenoid (fig 255) Ossification of the ethmoid begins in the fifth or sixth fetal month, but fusion of the centers does not begin until the sixth year and is not completed until the seventeenth year The perpendicular plate ultimately unites with the vomer, between the forty fifth and fiftieth years

The *vomer* (fig 255) is situated in the postero-inferior portion of the nasal septum It is thin and irregular, and is quadrilateral in shape The posterior border projects toward the nasopharynx and separates the choanae. The inferior border articulates with the nasal crest of the maxillae and palatal bones. The superior border is the thickest and is divided into two alae which articulate with the rostrum of the body of the sphenoid. The anterior border is grooved for the reception of the septal cartilage. The anterior extremity of this border abuts on the incisive crest of the maxillae and is of great surgical importance, because it is here that the lower segment of the septal cartilage which supports the nasal tip is inserted. In submucous operations in which the thickened vomer suffers resection, especially when the adjacent nasal spine has been sacrificed, there is a likelihood of a sinking of the dorsum and a consequent lowering of the tip of the nose. The ossification centers in the vomer appear at about the eighth week of fetal life. During its development the vomer exerts vertical pressure on the bridge of the nose by way of the ethmoid and septal cartilage, and this pressure continues up to puberty This explains the failure of the forward extension of the nose in disease or injury to the vomer occurring before puberty The remaining osseous elements

of the septum serve as articulating points for the vomer, ethmoid bone, and septal cartilage (fig 249)

Development and Function of Nose

Development The shape and racial characteristics of the nose are not well defined until after puberty In the newborn the bridge is low and the nose proper relatively broad and stumpy Embryologically, the external nose develops as an outgrowth of the brain About the third week of fetal life two areas of thickened cellular ectoderm designated as the "nasal areas," appear on the under surface of the forebrain In the fourth week these areas become the "nasal pits" which are separated by a broad mass of tissue, the frontonasal process (fig 721) This process undergoes differentiation into a medial and two lateral parts, which form the primitive nasal walls At this stage the maxillary processes grow anteriorly and fuse with the frontonasal process to shut off the communication between the nasal pits and the oral cavity. Failure of these several fusions or delayed growth of some of these elements leads to cleft palate, cleft lip, and various types of nasal disfigurement, such as a depressed, bifid, or double nose resulting from an imperfect union of the frontonasal plates in the midline At the lower margin of the frontonasal process are located (1) the infranasal area destined to form the philtrum, nasal septum, and maxillae, and (2) the triangular area of His which becomes the dorsum The region between these two areas gives rise to the border, columella, and tip of the nose (p. 1122)

After the sixth week the intranasal plug of epithelium is shed, and the nares become patent Failure of this process of exfoliation leads to atresia (p. 737)

Function The nose is admirably constructed for the performance of the functions of respiration, phonation, olfaction, and filtration, as well as for the ventilation and drainage of the sinuses and nasolacrimal apparatus

The respiratory function is probably the most important The amount of air entering the nose every hour is estimated at about 21 cubic feet Before this air reaches the larynx, its temperature is elevated to that of the body and it is saturated with moisture and freed from foreign material Since all of this must be accomplished in an area of approximately 7.5 cm , it is essential that the current be delayed, and that as much air as possible come in contact with the vascular lining of the canal Retardation of the flow is produced by the arched contour of the canal between the nares and the nasopharynx and by the points of constriction formed by the projecting turbinate bones along its course These narrowed areas also make possible a maximum contact of the air with the vascular lining, since they serve to split the current into many thin layers as it passes through The size of the constrictions varies in accordance with the temperature of the surrounding atmosphere, being controlled by the turgescence of the erectile tissue lining the canals Thus, when the weather is cold and dry, and the inspired air demands a more than usual amount of warming and moistening, the erectile tissue swells, thereby narrowing the intranasal spaces and delaying the flow of air. Conversely, when the atmosphere is extremely warm and damp, the conchae shrink and permit of a faster passage of thicker streams of air. It has been computed that at 70°F. the amount of heat required to raise the temperature of the inspired air to that of the blood is 70 kilocalories, and that the supply of moisture necessary, on the basis of an average hourly intake of 21 cubic feet, is approximately 40 cc per hour.

Dust particles and bacteria are prevented from reaching the nasal mucous membrane by becoming entangled in the vibrissae in the vestibule. Those which escape are either expelled by the action of the ciliated epithelium or are destroyed by the chemical properties of the mucus secreted by the lining membrane.

As an accessory organ of phonation the nose acts in the capacity of a resonating chamber and adds quality, color, and individuality to the speaking voice. When the nasal fossae are obstructed, the voice becomes flat and colorless. In the production of nasal tones, as when pure vowels are sounded, the air in the nasal fossae vibrates freely, the timbre being produced by the action of the soft palate only partially shutting off the nasopharynx. In the formation of consonants four different processes are involved, resulting respectively in resonants, explosives, vibratives, and aspirants. In the sounding of resonants the nasal fossae are quite free, and the oral aperture is shut off, while in the production of the other consonants the nasal cavity is completely shut off (fig 717)

The olfactory sense in man and in other primates is relatively rudimentary During expiration the air passing out of the pharynx does not reach the olfactory region but is confined to the plane of the posterior nares. Hence, odors on the expired breath are not subjectively appreciated When the mucosa between the respiratory and olfactory portions of the nose is inflamed, the sense of smell is lost.

FIG 256 Types of nasal fractures. (Kazanjian)

Finally, the nose has various motor, sensory, trophic, and vasomotor reflex functions. A single example will suffice to explain the general principle. When the nasal mucous membrane is stimulated, there is a reflex twitching of the facial muscles, a movement of the eyeballs, and a motion of the head to one side These are accompanied by a congestion of the blood vessels and an increased secretion of the nasal glands culminating in an expiratory blast from the nose.

NASAL FRACTURES

The exposed position of the structures forming the nasal pyramid renders them more subject to traumatism than other parts of the face. Fractures are common and may be unilateral or bilateral, linear or comminuted, depressed or overriding They may involve any or all of the bony elements of the nasal pyramid and are usually compounded internally because of the close adherence of the mucous membrane to the bone (fig 256) The lateral cartilages and cartilaginous septum follow the osseous displacements and may be torn away from their attachments (298)

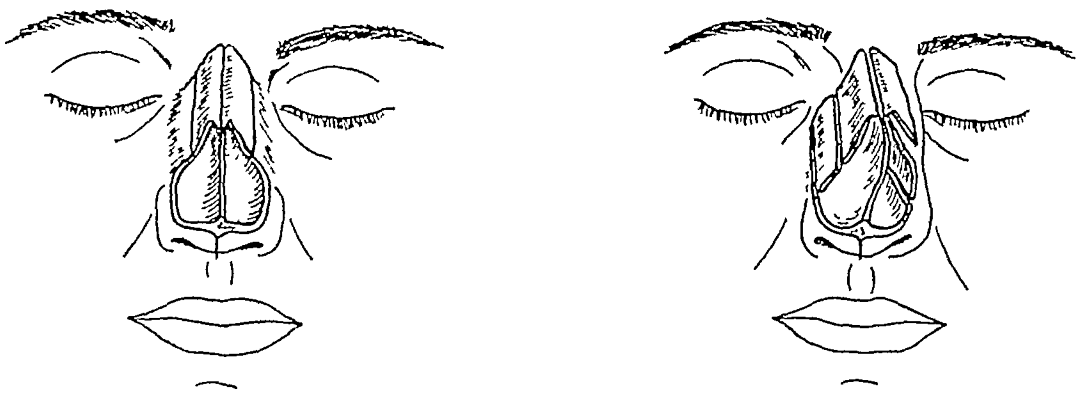
Unfortunately nasal fractures do not always receive the attention they merit. The simple types are apt to be treated as trivialities at the time of the accident, or may even be entirely overlooked, while the more complicated forms, being usually accompanied by more serious injuries, are necessarily neglected because of the more urgent claims

of the associated conditions Improper management of these injuries not infrequently results in serious consequences (23, 24, 299) In addition to producing deformity, they often lead to obstruction of the airways which may call for subsequent difficult submucous resections and, in the case of children, may interfere with the normal development of the nasal framework Seigall and Mancoll (284) are of the opinion that these injuries when neglected predispose to atrophic rhinitis

Mechanism of Nasal Fractures

Nasal fractures almost invariably result from direct violence, and their character and extent will depend for the most part upon the angle at which the force was applied, the amount of trauma, and the size and shape of the traumatizing agent

When fracture occurs as a result of force applied to the lateral aspect of the nose (fig 257), the nasal bones are carried in the same direction as the force The bone on



a b

FIG 257 Nasal fracture produced by lateral force *a*, normal position of nasal elements *b*, result of blow applied to right side At point of impact nasal pyramid flattened and concave, nasal bones separated from attachments Left nasal wall convex Septum displaced in direction of force For details, see text (Gillies)

the side of impact is driven to the opposite side, being violently separated from its fellow, from the frontal bone, and from the superior maxilla, beneath which it becomes locked The opposite wall of the pyramid is also dislodged from its attachment and is pushed outward and made to override the frontal process of the maxilla on that side These fractures are evidenced by a concavity at the site of impact and a convexity on the opposite side

When the blow is delivered from in front, a relatively greater force is necessary to produce fracture, since the nasal bones are buttressed by the frontal processes of the superior maxillae, the nasal spine of the frontal bone, and the perpendicular plate of the ethmoid By the same token, when fracture does occur, it is usually associated with comminution of the supporting structures of the nose, as well as injury of other bones of the facial compound (226, 249) Not infrequently the force required to cause these fractures is so great as to inflict damage upon the intracranial and orbital contents (338) If the frontal blow is delivered high up on the nasal arch, the nasal bones are driven backward between the frontal processes of the maxillae and forced beneath the frontal bone or even beneath the cribriform plate of the ethmoid, producing a flattening of the nasofrontal angle If delivered in the middle of the arch, there results

a separation of the nasal bones from each other and from the frontal processes of the maxillae which they overlap, and a subsequent splaying of the arch. If the frontal processes of the maxillae are also fractured and comminuted, the whole nasal arch may be driven backward, leveling the nose with the face, the septum being crushed or buckled beneath the in-driven bones. If the violence is applied to the lower part of the arch, the septum will necessarily follow the line of the force, and may be fractured, with comminution, impaction and overlapping of its fragments. The most common sites for such an injury are the posterior ⅔ of the cartilaginous section and the anterior half of its bony portion. If the force is not sufficient to fracture the septum, the latter may become buckled or displaced. Frequently, the inferior end of its cartilaginous portion springs out of the shallow groove in the vomer and maxilla and is deflected obliquely across the nasal groove, appearing in the nostril as a free cartilaginous ridge covered with skin As a result of the dislodgement the ala and nostril on the side of the lateral deflection are widened, while on the opposite side the ala is flattened and the nostril narrowed, the airway being either partially or completely obstructed (fig 346) In addition, the septal dislocation deprives the tip of the nose and columella of support, causing the tip to droop and the columella to become oblique restracted, or distorted

When the force is applied from below, the entire nasal pyramid may be separated from its osseous attachments and be telescoped upward obliterating the nasofrontal angle. When applied from above, the bony elements may be displaced downward lengthening and flattening the nasal arch

A moderate force applied directly to the nose, as, for example, in a fist fight, is likely to cause localized contusions and lacerations of the soft parts, a greater force will produce a nasal fracture of the greenstick variety or a dislocation But when the impact is more diffuse as in the case of automobile accidents the nasal fracture is usually impacted and associated with fractures and lacerations of adjacent facial structures (26)

Diagnosis

A history of a blow on the nose accompanied by a sense of the bones giving way, and associated with nosebleed, ecchymosis about the eyes, pain, and swelling, is presumptive of a nasal fracture If inspection reveals a marked flattening of the nasal arch or a displacement showing a concavity on one side and a convexity on the other, diagnosis may be made at a glance, but unfortunately inspection is of little value unless the patient is seen immediately after the injury, since swelling of the soft tissues takes place rapidly and masks the deformity Incidentally, care must be taken to avoid mistaking a pre-existing asymmetry or flatness for a recent fracture. Intranasal examination may help to substantiate the diagnosis by disclosing a deflection of the septum and a laceration of the mucous membrane

Roentgenography is on the whole unsatisfactory In children it is of no value, due to the cartilaginous character of the nasal pyramid and in adults, while it shows the presence of a fracture, a separation of the nasal bones, or an extension of the fracture into the frontal sinus or facial skeleton, it fails to reveal malalinement of the bones. However, since nasal fractures often become a matter of litigation, it is advisable to secure roentgenograms of the injured part before during and after treatment for the protection of the hospital, the surgeon, and the patient. A carefully made lateral view will show more than an anteroposterior view

While a definite diagnosis of nasal fractures is often impossible, nevertheless, in view of the serious consequences which not infrequently follow these traumatisms if neglected, it is considered sound practice in doubtful cases to treat the condition as though it were a fracture until proven otherwise

Management of Recent Fractures

Care of Soft Parts

Injuries of the soft parts of the nose present no special problem and are treated in a manner similar to wounds elsewhere (p 265) Briefly, their management will depend upon the character of the wound, the likelihood of contamination, and the time which has elapsed since the receipt of injury As in all wounds, the control of hemorrhage is the first consideration This can usually be accomplished by external applications of ice and by the use of intranasal tampons A practicable pack is a large, soft, rubber finger-cot introduced into the nares and inflated until it produces the required pressure A history of soil contamination calls for the administration of 1500 units of antitetanic serum immediately following the injury

After hemostasis has been secured, the skin of the nose and face is scrubbed with soap and water and wiped with ether All embedded foreign bodies, such as road dirt, should be carefully removed (p 270), otherwise, they may remain as permanent tattoo marks after healing has taken place Small bone fragments, if clean, should not be removed, as they help to maintain the nasal contour and seldom undergo sequestration, due to the good blood supply of the nose The nasal fossae are carefully cleaned, and all blood-clots and loose foreign bodies are irrigated out with warm boric acid or hydrogen peroxid solution Septal hematomata are common, appearing as pale to dark red swellings obstructing the nostrils Should they be encountered, they must be promptly evacuated through a horizontal incision made at the lowest part of the swelling, for if disregarded, they are likely to become infected and give rise to septal abscesses followed by necrosis, which in children may interfere with the future development of the nose Displaced and even detached soft tissues should be carefully cleansed, returned to their normal locations, and sutured in place Roy (261) reports a case wherein a completely avulsed ala survived after being sutured back in place 3 hours following its separation.

If the wound is superficial and comes under observation within the first 12 hours, it should be pared sparingly and the margins approximated directly, an intradermal suture being used, to minimize the final scar If the skin loss is too extensive to permit of direct approximation, the raw area may be covered with a graft taken from the upper eyelid or the postauricular region (p 116) In the case of through-and-through wounds opening into the nasal cavity the mucous membrane and perichondrium require separate approximation Should the septum or lateral cartilages be displaced, they must be realined and immobilized before the wound is closed When the full thickness of the nose has been destroyed, the skin should be sutured to the mucous membrane, to prevent subsequent contraction and distortion

Wounds seen after 12 hours are drained for 24 hours, after which time they are sutured, provided signs of infection are absent Otherwise, suturing is delayed until the infection has cleared up (p 274).

Care of Hard Parts

Due to the vascularity of the nasal elements, ossification following fracture occurs rapidly, the fragments becoming incorporated in a callus in an incredibly short time For this reason, the displaced fragments must be restored to their normal relations as soon as possible after the injury (14) The longer the interval between the receipt of the fracture and its reduction, the more difficult it becomes to separate the fragments from their false positions, and frequently good results cannot be obtained by late treatment, even after complete mobilization of the fragments

The repositioning of the fragments can be accomplished under either local or general anesthesia Local insensibility is obtainable by packing the nasal fossae with gauze strips soaked in an equal mixture of a 10 per cent solution of cocain and 1 1000 adrenalin (p 669) The packs are inserted into the nose at the site of the fracture and allowed

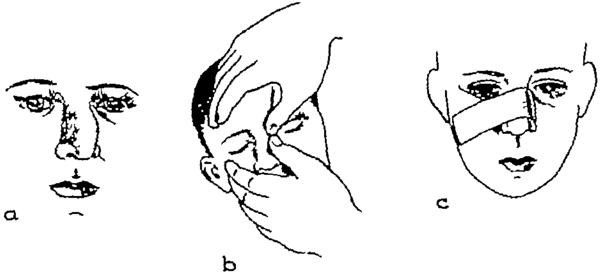


FIG 258 Reduction of non-impacted nasal fracture. *a* showing nose displaced to left, as result of force applied to right side. *b* reduction by direct thumb-pressure on deviated side. *c* adhesive strap carried from deflected side across dorsum and fastened to opposite cheek, to counteract tendency of displacement to recur (Seiffert)

to remain in place for 10 to 15 minutes. Local infiltration with procain had best be avoided, since it increases the swelling already present If general anesthesia is to be employed, the endotracheal method is preferable, as this best prevents the entrance of blood into the respiratory passages.

(1) **Technic of Reduction.** If the entire nasal pyramid is displaced to one side and the fragments are not locked or impacted, the nose can be forced into the midline by the application of direct pressure with a gauze-covered thumb on the deviated side (fig 258) If the nose is deviated but locked in a faulty position, it must be forcibly released before reduction can be accomplished. A convenient instrument for the disimpaction of the bones is a Walsham (323) forceps the blades of which are about 7 cm long and concave so that only the tips meet (fig 259) If such an instrument is unavailable, a Kelly forceps serves the purpose very well The forceps, well padded to prevent injury to the soft parts is applied to the concave side of the deformity—that is the side nearest the median line—one blade in the nostril resting on the inner surface of the bone and the other, protected with rubber tubing, placed against the skin With the thumb guiding the forceps on the outside, the freed fragments are reduced

During this procedure the mechanics of the displacement must be kept in mind. Since the edge of the concave side is locked under the adjacent maxilla, the forceps must be so manipulated as to force the bone in an upward and outward direction, in order to unlock it As soon as the elevation is sufficient to overcome the overriding, the bones will snap back into place with an audible click In the absence of comminution no further intranasal manipulation is required, any subsequent molding of the bridge being accomplished by external digital pressure

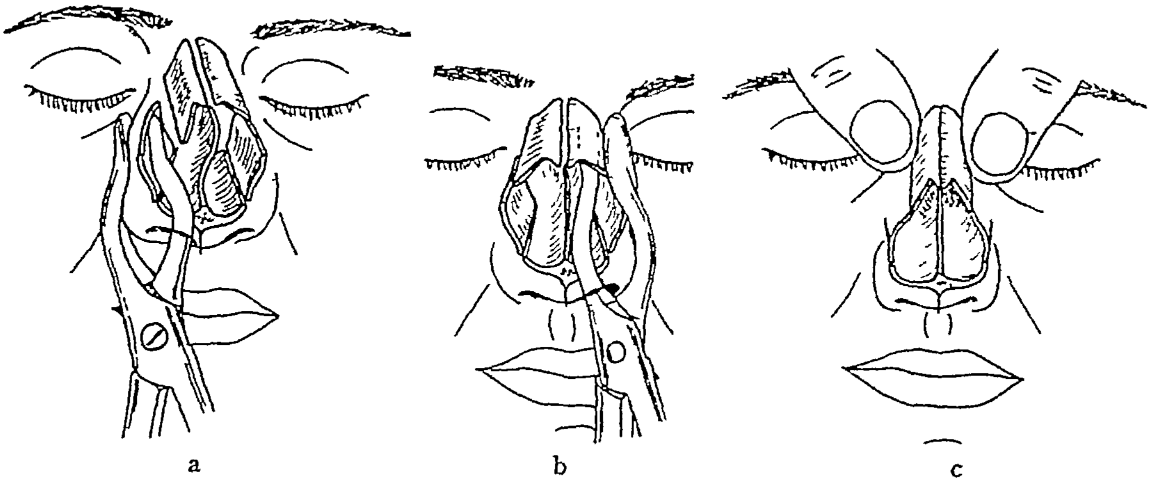


FIG 259 Reduction of impacted fracture *a*, forcible release of fragments Forceps applied to concave side, impacted fragment released from beneath maxilla by manipulation in upward and outward direction *b*, nasal bones elevated on convex side *c*, with fragments unlocked, bridge molded to normal position by digital manipulation For details, see text. (Gillies)

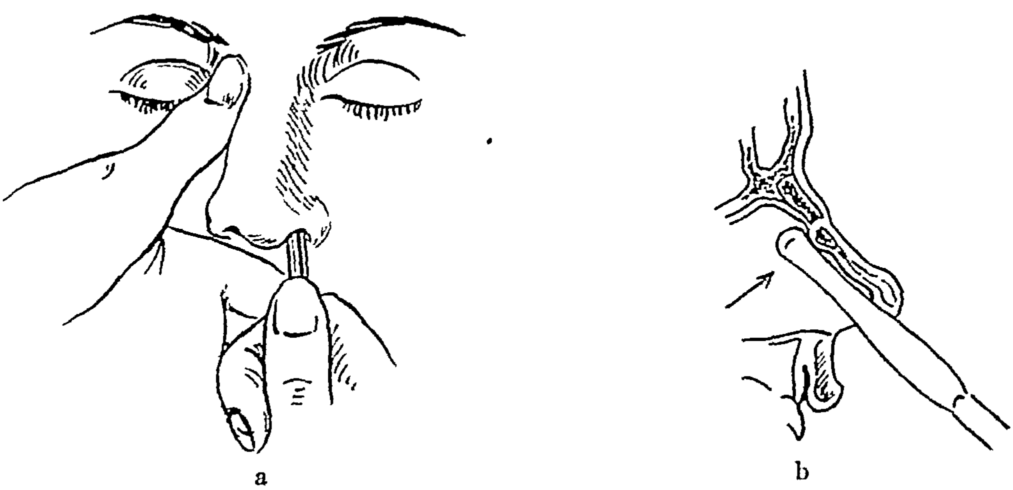


FIG 260 Reduction of depressed nasal fracture *a*, blunt instrument placed beneath depressed fragments, and bone elevated by upward and outward force Instrument guided by left thumb held over apex of deformity *b*, sectional view, arrow showing direction of force (Christopher's Surgery)

If, as a result of force applied anteriorly, the nasal arch is merely spread, it may be elevated and the nasal bones repositioned by direct pressure with gauze-covered thumbs on both sides of the nose (fig 259-c). Should the fragments be depressed, they may be lifted up with a blunt instrument, such as the handle of a nasal rasp or a urethral sound. The instrument is inserted into the nostril beneath the displaced nasal bone, and the thumb of the left hand is placed over the apex of the deformity to guide its course. Strong upward and outward pressure is applied until the bones fall into their normal positions (fig 260). If the bones are comminuted, each fragment will require individual

reduction In such cases an elevator is placed in the nostril beneath the fragment, and the arch is re-formed by the exertion of gentle digital counterpressure externally

Following the reduction the interior of the nose is cleansed, and blood-clots and foreign bodies are removed by irrigation with warm boric acid solution. An intranasal examination is then made to determine the position of the septum. Usually the reassembling of the osseous portions will liberate it and allow it to spring back automatically into its former location. It this does not occur, the septum is grasped with an *Asch forceps* and rocked from side to side until it clears the maxillary spine and finds its normal place in the septal groove Should this manoeuver fail, reduction can usually be brought about by placing a small elevator beneath its dislodged edge and prying it over the edge of the maxillary spine into the septal groove. The nostrils are then packed with xeroform gauze, loosely enough to prevent locking up of the secretions yet sufficiently tight to prevent the formation of hematomata. The packing is removed in 24 hours

If the patient does not come under observation until marked edema and ecchymosis have already set in, rather than subject the tissues to further trauma and predispose them to infection, it is advisable to wait 3 or 4 days for the swelling to subside. In the meantime cold compresses are applied in an effort to hasten the process. In no event should reduction of the fractured bones be delayed for more than a week since after this period preliminary ossification will have taken place. Repositioning of the cartilages, however, may be postponed for as long as 3 weeks, if necessary, inasmuch as organization of these structures does not proceed as rapidly as that of bone.

(2) **Stabilization of Fragments.** The nasal bones, unlike long bones, are not subject to muscular displacement when fractured, and after reduction they remain in the position placed unless comminuted. Theoretically, then, in the case of *non-comminuted fractures* no packing or splinting is required. Practically, however, in order to offset any possible disturbance or accidental trauma on the part of the patient through violent sneezing or turning in bed, and also to prevent postoperative swelling and the formation of hematomata, stabilization of the fragments for the first 48 hours is desirable.

The materials commonly employed for the immobilization of these simple fractures are (1) Stent's modeling compound. The compound is softened in a hot water bath, covered with a piece of felt to protect the skin, molded to the adjusted nose, and allowed to harden, after which it is fixed in place by adhesive strips extending from the forehead and across the cheeks (fig 261) (2) Metal. A thin sheet of copper or aluminum lined with surgical felt may be cut out in the form of a butterfly, molded to fit over the nose and cheeks, and held in place with adhesive strips. (3) Adhesive strips. If there is a tendency on the part of the fragments to become deflected, strips of adhesive tape 2 to 3 cm. wide may be carried from the side toward which the nose is bent across the dorsum and fastened to the opposite cheek (fig 258-c) All forms of nasal splints should be removed in 48 hours. Retention after this period may cause undue pressure, and the inability to observe the repositioned bones may allow them to undergo organization in what may prove to be an incorrect position

In the case of *comminuted fractures*, however, especially when there has been a loss of septal support, satisfactory alinement can be maintained only by splinting the adjusted fragments until organization has taken place. Various plans have been suggested for retention, both intra and extranasal, but none is entirely satisfactory An intranasal pack sufficiently firm to maintain elevation and immobilization of the frag

ments tends to spread the nasal arch, and, by locking up the nasal secretions, predisposes to infection In the application of external splints it is difficult to gauge the correct amount of pressure If applied too tightly, there is the danger of pressure necrosis, and if applied too loosely, immobilization is not effected

Nasal splints may be classified according to their points of anchorage, as (1) direct sutures of the fragments, (2) headbands with adjustable mechanisms designed to exert

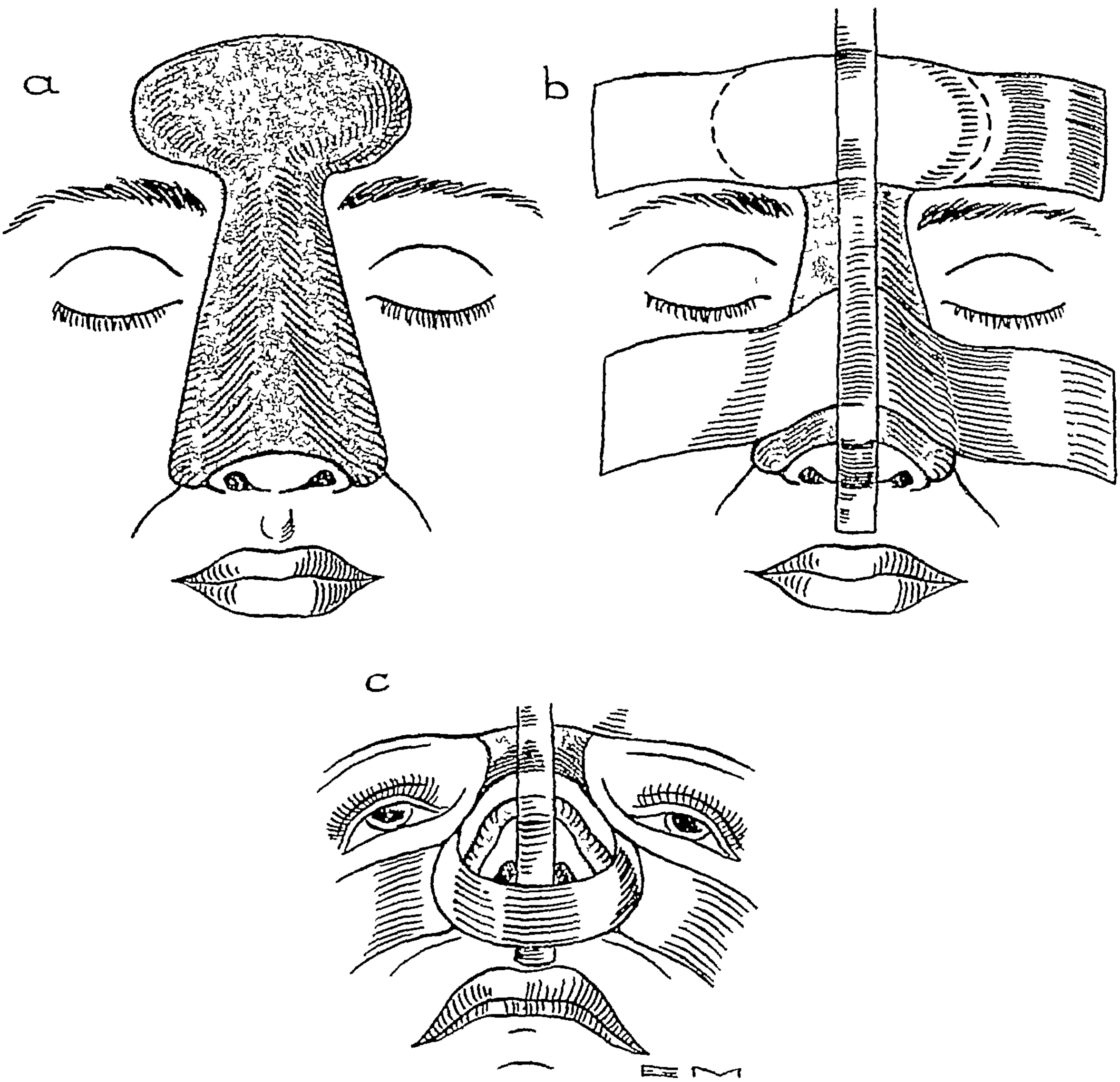


FIG 261 Immobilization following reduction of nasal fracture *a*, softened stent lined with felt molded to nose *b*, compound held in place with adhesive strips *c*, basal view

pressure on the nose (298) (fig 262), and (3) adjustable nasal splints attached to the teeth When the nasal bridge tends to spread, a through-and-through mattress-suture of fine wire or silkworm-gut may be passed through the whole thickness of the nose, entering and emerging at points between the bone fragments, and tied over lead plates or small rolls of gauze (222) (fig 263) If the nasal pyramid has been separated from its attachment to the frontal bone, the fragments are best retained in their correct relationship by a #22-gauge silver wire passed through drill holes in the frontal and nasal bones (299) In the case of deflected fractures Blair (13) passes a silver wire

obliquely downward through the lower border of the adjusted bone, and the lower end of the septum, brings it out through the gingival fold on the opposite side, and anchors the ends around a molar or premolar tooth under sufficient tension to immobilize the

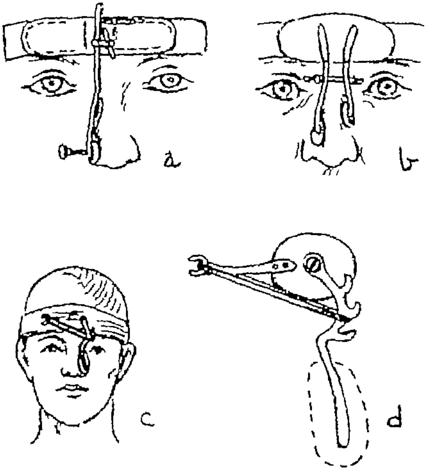


FIG 262. Headbands with adjustable mechanisms, for immobilization of fragments following nasal fracture with tendency to deflection. *a–b* Joseph splints *c–d*, Kazanjian splint. *d* Lateral view showing elastic band attaching splint to headgear

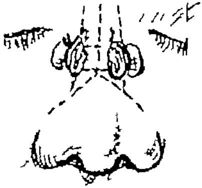


FIG. 263 Through-and-through mattress-suture passed between fragments and tied over gauze rolls, for immobilization of fragments with tendency to spread. (New)

part in its normal position (fig 264) The objection to this procedure is the danger of pressure necrosis of the skin which is apt to take place even after the insertion of a gauze roll beneath the wire loop

A practicable splint is that of Kazanjian (135) (fig 265-c): "A 16 gage wire, 2 inches long, is bent to form a 'U.' To one of the arms of the 'U' small metal hooks are soldered A small piece of dental composition is softened and added to the smooth arm of the 'U' wire This is then introduced to the nose well up under the comminuted nasal bone and pressed against the root of the nose When this is removed we find the soft plastic dental composition has molded itself to the inner surface of the nose. After trimming the surplus composition, it is placed back into the nose again. A bar (12 gage wire), the lower end of which is supplied with hooks, is extended from the forehead

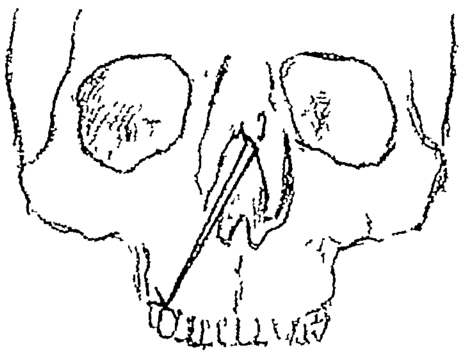


FIG 264 Silver wire passed through nasal bone on deflected side, brought out through gingivolabial fold on opposite side, and anchored to molar tooth under sufficient tension to maintain parts in normal position Used when fragments tend to deviate to one side (Blair)

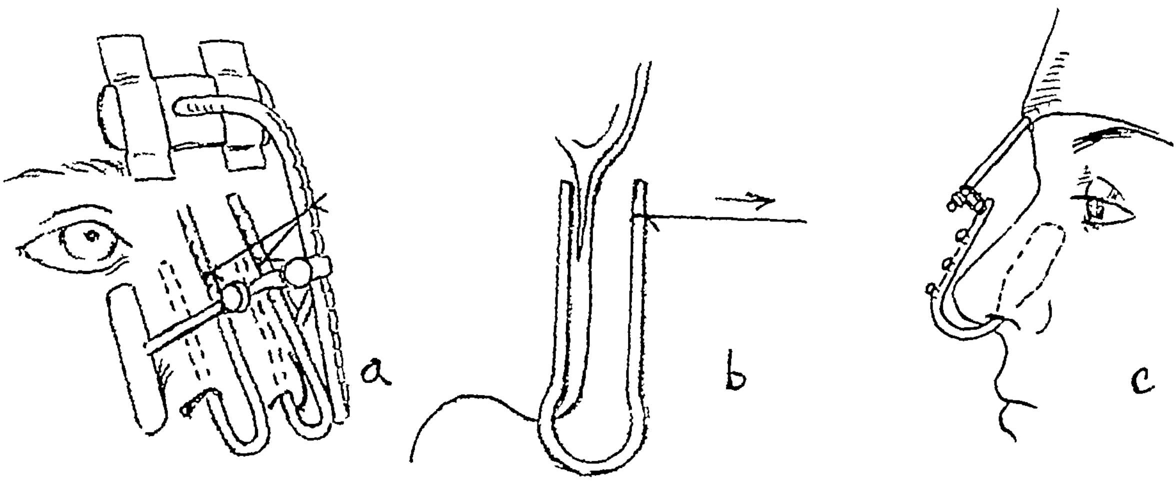


FIG 265 Types of intranasal splints used to immobilize fragments following reduction of comminuted fracture *a*, Watkin's double U-shaped splint *b*, sectional view *c*, Kazanjian's U-shaped splint Modeling compound attached to one limb of splint and placed beneath repositioned bone, other end fixed to forehead For details, see text

to the nose and is held in place by either a plastic bandage or any other secure means (the writer uses gutta percha headgear) A small elastic band connects the two attachments The force of the elastics need not be great, but merely enough to hold the bone fragments in position "

Watkins (326) employs a double U-shaped splint One pair of limbs are introduced into the nostrils, and traction is exerted on the other pair by passing a thread between them and a mast projecting from a head cap The proper tension can be obtained by altering the angle between the limbs of the arch by means of a screw Figure 265-a, b is self-explanatory.

(3) **Complications.** Patients who have been subjected to nasal traumatism should be carefully watched for symptoms of complications. Every effort should be made to prevent infection, since this may lead to osteomyelitis, abscess, and necrosis of the bones and cartilages. Should the emphysema and swelling persist for over a week or 10 days, a search should be made for foreign bodies or sequestra which, if found, must be removed. The treatment of nasal fractures complicated with fractures of other bones of the facial compound is discussed in Chapter XIV

Management of Old Unreduced Fractures

After a period of 3 or 4 weeks following an unreduced nasal fracture the dislocated fragments undergo ossification in their faulty relationships The original form of the nose can then be restored only if the dislocated bones and cartilages are separated from

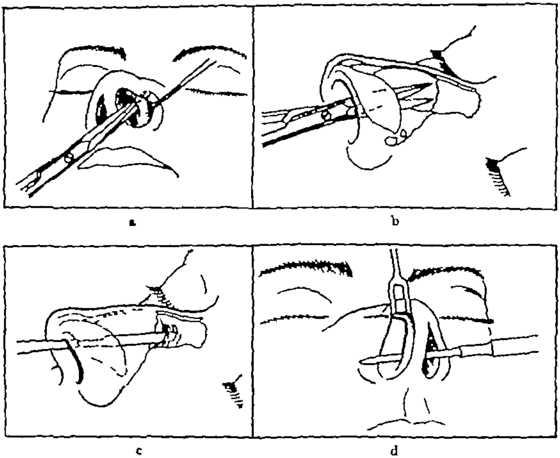


Fig 266 Exposure of nasal framework for reduction of old unreduced nasal fracture. *a*, incision made between upper and lower lateral cartilages. *b* skin separated from subjacent structures *c*, periosteum elevated from nasal bones *d* membranous septum cut through. (Fomon, Ann Surg., 1936)

their false attachments, reassembled in their proper relationships, and stabilized until ossification has taken place Unfortunately, in such cases complete restoration of the normal contour, even after free mobilization of the fragments, is often impossible, owing to absorption, callus formation, deviation, and distortion of the bony and cartilaginous elements during the process of organization (57, 65, 82, 83)

The treatment of old unreduced nasal fractures is the same as that accorded nasal deformities from other causes, and the details of the technic will be discussed later

Only passing mention of it will be made at this time The nose is aseptically prepared and anesthetized (p 669). To expose the nasal pyramid, an intranasal incision is made between the upper and lower lateral cartilages, and through this opening the skin and periosteum over the nose is elevated and the membranous septum cut through to the nasal spine (fig 266) With the nasal arch thus bared, the further management will be governed by the nature of the deformity

Management of Osseous Structures

Should the nasal dorsum show irregularities due to ossification of the fragments in an overriding position, the dorsal line is straightened by following the technic employed for the removal of a nasal hump Briefly, the excess bony and cartilaginous elements are cut through with a saw (fig 267), and the section thus liberated is extracted with a stout forceps Any remaining irregularities are smoothed off with a rasp The bridge, which now appears abnormally wide, is narrowed by performing an osteotomy

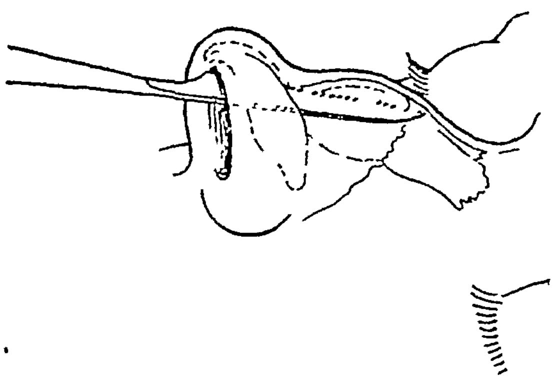


FIG 267 Reduction of dorsal irregularity Nasal saw in position at exact level at which profile is to be reduced (Fomon, Ann Surg , 1936)

through the frontal processes of the maxillae and shifting the walls medially (fig 268). All excised fragments of tissue are preserved, as they frequently prove useful for filling in small depressions remaining on the dorsum

If the dorsum is abnormally wide as a result of a traumatic separation of the nasal bones but shows no irregularity, the narrowing can be accomplished only by deliberately breaking the spring of the arch A saw is introduced through the intranasal incision, and the nasal bone on each side is cut through where it joins the osseous septum (p 689) Lateral osteotomies through the frontal processes of the superior maxillae are then carried out in accordance with the technic outlined on page 674 The frontonasal suture is fractured by thumb pressure The arch thus mobilized is re-formed by digital manipulation

Traumatic exostoses of the nasal bones or frontal processes of the superior maxillae can be planed off with a chisel or rasp

When, as a result of force applied from in front, the nasal bones have become depressed and impacted to form a traumatic saddle-nose, the management will depend upon the extent and location of the depression and the presence or absence of an external scar The various procedures for their correction are discussed in the section dealing with saddle-nose

When a lateral blow has resulted in a shifting of the nasal pyramid to one side, a

space must be created for its restoration to the midline of the face. This is accomplished by the removal of a triangular section of bone from the broad concave side of the nose,

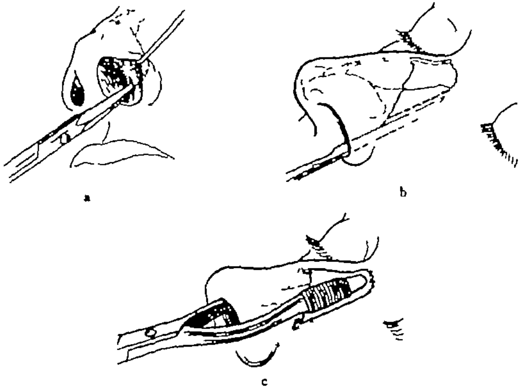


Fig 268. Narrowing of nasal bridge. *a* vestibular incision made for elevation of skin and periosteum. *b* saw inserted beneath periosteum on line with nasofacial groove, and $\frac{2}{3}$ of thickness of bone cut through. *c* fracture completed with forceps, and bone brought to midline (Fomon Ann Surg 1936)

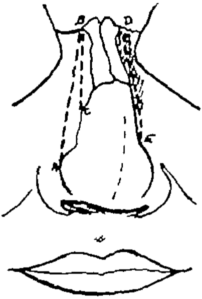


Fig. 269 Treatment of deflected nose. Triangle of bone *a–b–c* removed from broad concave side to equalize walls of nasal pyramid and permit shifting to median line. *d–e*, line of osteotomy on narrow convex side, to mobilize nasal elements Nasal structures thus freed shifted toward median line obliterating space left after removal of triangle. (Fomon, Ann Surg., 1936)

the size of the triangle being regulated by the angle of deviation from the normal (fig 269) With both thumbs placed on the convex side of the nose (protected with a

gauze pad), and the fingers over the opposite zygoma, sufficient force is exerted to fracture the nasofrontal suture and the perpendicular plate of the ethmoid (fig 317-d). The narrow convex side is then shifted into the space created by the removal of the triangular section (p 690)

Management of Cartilaginous Structures

As a rule, the same trauma that produced the nasal fracture also brings about various fractures, distortions, and displacements of the cartilages and septum. Therefore, these structures should be inspected and treated as soon as the osseous elements have been repositioned If the upper lateral cartilages are found to be spread as a result of frontal trauma, they are separated from their septal attachments, replaced in their proper anatomic locations by digital manipulation, and immobilized with 1 or 2

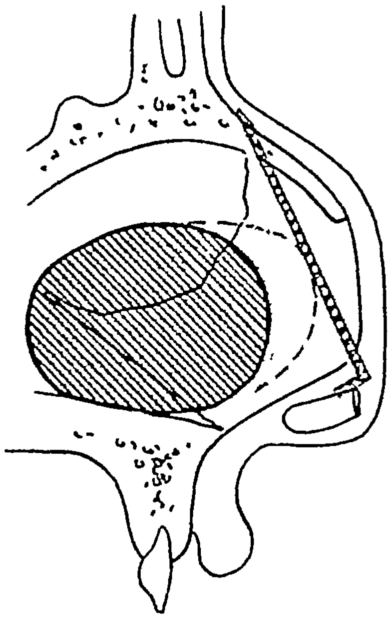


FIG 270 Correction of septal deflection by submucous resection, showing importance of attending to dorsal irregularities prior to resection Wide dotted line indicates reduction of dorsum to proper profile projection, shaded area, permissible amount of septum to be excised, sufficient buttress being left to support dorsum, interrupted line, too extensive resection, resulting in saddle-nose deformity from loss of support (Joseph)

catgut sutures (fig 330) If they show thickening or buckling as a consequence of traumatic chondritis, these irregularities are shaved down with a sharp scalpel

If the angles of the lower lateral cartilages have been spread, producing a wide tip, or separated, creating a cleft tip, or one or both cartilages have become hypertrophied, buckled, or displaced, resulting in a twisted tip, such deformities must now be corrected, in order that the reconstruction may be complete. The various methods for their correction will be found in the section devoted to deformities of the lower cartilaginous vault

In all old unreduced fractures the septum must be restored as a median partition, so that it will support the bridge and afford a free airway, its caudal margin relocated on the floor of the nose, in order to give form to the columella, and its anterior margin brought forward, so that the nose will project from the face at an angle of 30°. Frequently, the reassembling of the nasal elements will be sufficient to liberate the septum

from its cramped position and allow it to spring back into place without further manipulation If such spontaneous adjustment fails to occur, a judicious submucous resection at the angle of the deflection will often permit of its repositioning But this should not

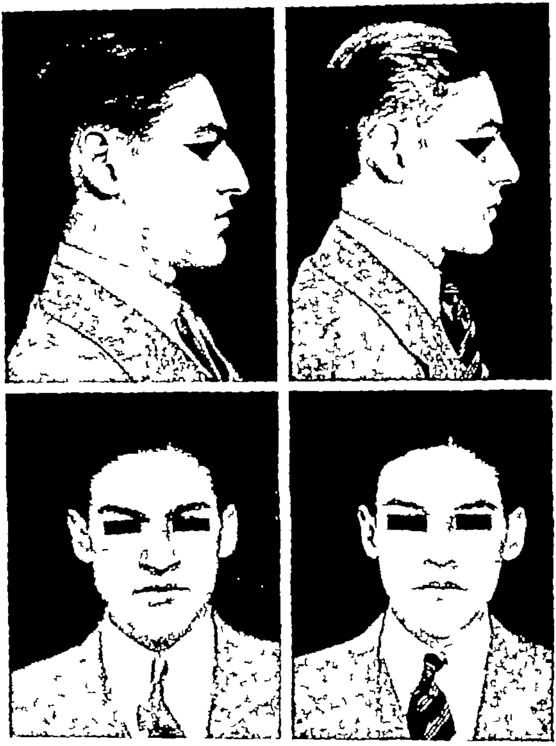


Fig 271 Results following reduction of old unreduced nasal fracture. (Fomon Ann Surg., 1936)

be attempted until the bony and cartilaginous arches have been re-established, otherwise it may be found that when the dorsal irregularities are excised, there will not be sufficient septal wall remaining for the support of the dorsum (fig 270)

Following the readjustment of the nasal structures in their correct relationships

the columella is reunited to the lower edge of the septum by means of 2 silk sutures (p 674) The nose is lightly packed with xeroform gauze, and a stent dressing is applied to offset the possibility of disturbance by the patient in the early postoperative period At the end of 48 hours the splint is discarded, the xeroform packing is removed, and the nostrils are cleansed of incrustations with hydrogen peroxid. The 2 sutures are removed on the fifth or sixth day (fig 271).

NASAL DEFORMITIES

Etiology

An appreciation of the etiologic factors underlying nasal deformities is essential, since failure to take them into consideration will often nullify the results of the most technically perfect surgical procedure

Traumatic Causes The nose, being a salient feature, is subject to violence at all periods of life In the prenatal state deformations are said to be caused by pressure of amniotic bands, insufficiency of liquor amnii, adhesions, excessive contractions of the uterus, or traumatisms applied to the abdomen of the mother During the course of a prolonged labor considerable pressure is apt to be exerted on the nose, owing to the position of the fetal head in the birth canal, and despite the elastic pliable consistency of the nasal structures, permanent nasal deformity may result When forceps are employed in the delivery of an unrotated head high in the pelvic inlet, the tip of one blade is likely to lie against the base of the nose, distorting the organ Fortunately, in these cases much can be done immediately after birth to reshape the nose

In this era of crowded highways and congested traffic, children, with their uncertain gaits and active tendencies, are especially liable to nasal traumatisms Unfortunately, such an injury received in childhood, producing at the time no deformity and therefore regarded as of little importance, may cause serious interference with the future development of the nasal framework, the disfigurement becoming apparent only as the gradual growth of the nasal structures takes place In adults fractures and dislocations of the nasal bones and cartilages result chiefly from motor and industrial accidents, and here, as in the case of children, the deformity may not be manifest until some time after the accident, making its appearance following a traumatic osteitis or chondritis

Hereditary Causes Many hypotheses have been advanced in explanation of the cause of non-traumatic nasal disfigurements. Some investigators believe them to have a phylogenetic origin, and the fact that hereditary nasal deformities are unknown among animals and savages and are rarely found in semicivilized races lends color to the assumption The protagonists of this theory are of the opinion that in the process of evolution the forward cranial extension incident to the growth of the brain in its development from the anthropoid to the human form, encroaches upon the nasal bones and results in an unbalanced adjustment of the facial and cranial parts of the skull Th ... ramid, wedged between the unyielding frontal, maxillary, and ethmoid ... d position, and if the above assumption is true, any change in the ... ater will necessarily lead to buckling and deviation of one or more ... nced development of the adjoining facial bones is ... nasal pyramid An irregular expansion of the ... th of the remaining nasal elements, a

preponderance in strength of one of these bones over another causing a bending or dislocation of the weaker An overdeveloped vomer may crowd against the descending perpendicular plate of the ethmoid, causing distortion of the septum and dislodgement and asymmetry of the nasal structures which are dependent upon it for support. The normal high-arched palate (Gothic arch) of childhood may fail to descend, due to an underdevelopment of the maxillary bones. This lofty arch leaves less room in the vertical diameter for the growth of the vomer below and the perpendicular plate of the ethmoid above, and in the process of expansion these bones must necessarily encroach upon the septal cartilage between, thus affecting the morphology of the entire nose. Conversely, a hard palate which is too low may bring about a deformity by causing a downward dislocation of the nasal structures

Nasal deformities have also been explained on an ontogenetic basis. The facial features of the progeny of mixed races are unfortunately not a fusion but a conglomeration of the composing elements, wherein the genes which carry the disfigurement struggle for supremacy For instance, a large nose inherited from one parent may be crowded into a small face inherited from the other

Inflammatory and Degenerative Causes Inflammatory states, next to traumatisms, are probably the most common factors responsible for the production of nasal deformities As a result of syphilis, for example all the elements of the nose may be destroyed and replaced by a tough, tenacious, adherent scar (p 814) The disfigurement is characteristic. Due to the lack of supporting structures, the bridge falls in, and a saddle-nose is produced. Because of the loss of mucous membrane and the subsequent contraction of scar tissue, the tip and alae retract so that the plane of the nostrils assumes an upward position. The skin is glossy and anemic, and in time it too may be destroyed, the nose appearing as a hole in the face, with more or less conservation of the alae. Lupus (p 817) usually begins in the cartilaginous septum at the junction of the skin and the mucous membrane, and from there it spreads to the external surface Here the contraction of the scar tissue results in a downward bending of the tip and a narrowing of the anterior nares The bones are ordinarily not involved. Other inflammatory diseases causing nasal disfigurements by distortion and contraction are actinomycosis, glanders rhinoscleroma, and rhinophyma.

Degenerative disorders, such as abscesses, ulcerations, caries, and necrosis, add their quota to the production of nasal distortions. These processes begin as a hyperemia, but as bone is incapable of swelling, the tension in the Haversian systems rises, and the exudate forces its way between the periosteum and the bone. The pressure of the fluid eventually strangulates the blood supply, and there results an absorption of the nasal elements with consequent disfigurement.

Neoplastic Causes Neoplasms may cause deformity either by the exertion of intranasal pressure or by their external position. The most common nasal tumors are fibrosarcoma, fibro-angioma, papilloma, osteoma, carcinoma, sarcoma, and endothelioma (p 817)

Endocrine Causes Rickets produces a characteristic depressed dorsum, a tilted tip thick alae, and small nasal orifices. In myxedema the nose is distinctively broad and the alae are markedly thickened Other nasal deformities of this type are those that result from acromegaly, leontiasis ossea achondroplasia, and osteitis deformans

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General Examination

Prior to all contemplated nasal reconstructions a history should be obtained and physical and laboratory examinations made to determine the presence of any general or local factor which might have an adverse bearing on the outcome of the operation The facts thus obtained will frequently show that the deformity requires other than operative treatment For instance, the disfigurement may be due primarily to an endocrine disturbance, such as acromegaly, and therefore present a medical rather than a surgical problem Evidence of concurrent constitutional conditions, such as diabetes, cardiac disorders, and anemia, may modify the plan or even interdict the operation A thorough intranasal examination is essential for the detection of inflammation, infection, or mechanical obstructions to respiration This examination should be supplemented by nasopharyngoscopic and roentgenographic observations which may disclose unsuspected pathologic states Local conditions, such as pimples, boils, carbuncles, tonsilitis, and sinus infection, would contraindicate immediate surgical intervention Information should be sought regarding similar deformities in parents and relatives The patient should also be questioned regarding trauma and previous diseases of the nose

After the determination of the probable cause of the deformity, further examinations are necessary to ascertain whether or not the original causative condition still exists For instance, it would be unwise to correct a nasal deformity in the presence of active syphilis, acute inflammations, and infections of the nose The age of the patient also has a bearing on the situation In the case of children it is usually advisable to delay surgery until the nose has attained its full growth, while in the aged it may be best to forego the advantages of reconstruction and conceal the deformity by means of a prosthetic appliance The social status, occupation, and mental attitude of the individual must likewise be considered Under no circumstances should the surgeon allow himself to be persuaded by the insistent urging of a patient to perform some cosmetic operation solely for the purpose of influencing his state of mind Such procedures are often a cause of regret to the operator, since after a temporary improvement the patient is likely to return with other demands for operation In view of the less imperative indications, the later results will not be so acceptable, and the final outcome is likely to meet with dissatisfaction The remarks of Blair and Brown (13) on this matter are pertinent

"In rebuilding or in changing a nose, the surgeon is dealing with material facts related to anatomy and physiology, and with fundamental rules that have been formulated in regard to the proper ensemble of the facial elements, but, in passing upon the advisability of the attempt, he must also take cognizance of the patient's mental attitude If that has become a bit warped, it can in the end defeat the main objective, i e, pleasing the patient, regardless of the fact that the newly made nose might be surgically and artistically as near perfection as the available material and skill permit

"The psychology of patients who seek facial corrections should, therefore, be considered As a general working rule, the more pronounced the deformity or loss, the more likely is a reasonably good result to be acceptable, but, conversely, it is well to be cautious about embarking upon the correction of slight defects Adolescents of both sexes, especially those who ha[illegible] r employment, are more apt to be over-particular than are the more ma[illegible] patient's inability to state accurately

and succinctly the particular thing that displeases him should excite grave self-doubt in the surgeon's own ability to satisfy The same uncertainty should also excite the suspicion that the accused nose might not be the real fault."

Similarly Gillies (73) remarks "The size of the hump of a nose bears little relation to the misery of the patient and to the wisdom of advising its removal. The individual again has to be judged on his merits. Quite frequently some well-known actor or actress takes to the films and discovers some photographic blemish in the line of the nose which is undisguisable by the usual camera tricks The patient's livelihood would depend on a successful removal, and even when, as I have known, such patients would not dream of having the operation if it were not for their work, I think it would still be justifiable. Even in ordinary life a nasal defect may produce such an inferiority complex as genuinely to hinder the patient's happiness and progress. There is a well known class, however, which has a nasal complex not relieved by operation, however successful, and such patients are to be avoided. But the differential diagnosis between the genuine and the false is one of considerable difficulty The help of the psychologist is of great value when there is any doubt.'

Analysis of Deformity

Before attempting the correction of a nasal deformity it is necessary to have a clear mental picture of the end results to be achieved The proper form and dimensions of the nose to be reconstructed can be estimated only by a comparison of the deformed organ with some standard But obviously the creation of a single norm applicable to all faces is impossible, since the correct proportions of a given nose will for the most part depend upon the character of the structures which immediately surround it. Nor, indeed, would such a norm be desirable, since criteria of the ideal shape are by no means universally accepted, the eye being unconsciously influenced by habit and inherited taste For example, the facial proportions which would be pleasing to a Mongolian would by no means satisfy the esthetic perceptions of a Caucasian

However, although no standard norm can be determined, one may, by following the rules to be described, establish a "fictional norm" for each individual face, to serve as a basis for the calculation of the deformity The purpose of the following discussion is not to suggest that these "fictional norms" be slavishly copied to the extent of causing all individuals to be cast in a single mold. Nevertheless they will be found valuable in setting up a means of comparison. Judgment will be necessary in the application of the rules to be laid down For instance in certain individuals variations from fixed measurements and proportions, even though outside the normal limits, do not justify correction, as such deviations come under the heading of "special types," and in these cases one must bear in mind that "a specific variation from a fixed proportion not infrequently produces individuality "

The aim of reconstruction then, is not to obtain perfect symmetry but merely to bring an abnormality within the range of the norm for the specific type of individual. For example, to transform a saddle-nose into a Grecian one in a face in which a saddle nose within normal limits is a natural attribute, would be to violate the laws of form and create an abnormality In the laying down of dimensions for the "fictional norm," even though the discussion be limited to normal forms, a line must be drawn somewhere,

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General Examination

Prior to all contemplated nasal reconstructions a history should be obtained and physical and laboratory examinations made to determine the presence of any general or local factor which might have an adverse bearing on the outcome of the operation. The facts thus obtained will frequently show that the deformity requires other than operative treatment. For instance, the disfigurement may be due primarily to an endocrine disturbance, such as acromegaly, and therefore present a medical rather than a surgical problem. Evidence of concurrent constitutional conditions, such as diabetes, cardiac disorders, and anemia, may modify the plan or even interdict the operation. A thorough intranasal examination is essential for the detection of inflammation, infection, or mechanical obstructions to respiration. This examination should be supplemented by nasopharyngoscopic and roentgenographic observations which may disclose unsuspected pathologic states. Local conditions, such as pimples, boils, carbuncles, tonsilitis and sinus infection, would contraindicate immediate surgical intervention. Information should be sought regarding similar deformities in parents and relatives. The patient should also be questioned regarding trauma and previous diseases of the nose.

After the determination of the probable cause of the deformity, further examinations are necessary to ascertain whether or not the original causative condition still exists. For instance, it would be unwise to correct a nasal deformity in the presence of active syphilis, acute inflammations, and infections of the nose. The age of the patient also has a bearing on the situation. In the case of children it is usually advisable to delay surgery until the nose has attained its full growth, while in the aged it may be best to forego the advantages of reconstruction and conceal the deformity by means of a prosthetic appliance. The social status, occupation, and mental attitude of the individual must likewise be considered. Under no circumstances should the surgeon allow himself to be persuaded by the insistent urging of a patient to perform some cosmetic operation solely for the purpose of influencing his state of mind. Such procedures are often a cause of regret to the operator, since after a temporary improvement the patient is likely to return with other demands for operation. In view of the less imperative indications, the later results will not be so acceptable, and the final outcome is likely to meet with dissatisfaction. The remarks of Blair and Brown (13) on this matter are pertinent.

"In rebuilding or in changing a nose, the surgeon is dealing with material facts related to anatomy and physiology, and with fundamental rules that have been formulated in regard to the proper ensemble of the facial elements, but, in passing upon the advisability of the attempt, he must also take cognizance of the patient's mental attitude. If that has become a bit warped, it can in the end defeat the main objective, i.e., pleasing the patient, regardless of the fact that the newly made nose might be surgically and artistically as near perfection as the available material and skill permit.

"The psychology of patients who seek facial corrections should, therefore, be considered. As a general working rule, the more pronounced the deformity or loss, the more likely is a reasonably good result to be acceptable, but, conversely, it is well to be cautious about embarking upon the correction of slight defects. Adolescents of both sexes, especially those who have no regular employment, are more apt to be over-particular than are the more matured, and a patient's inability to state accurately

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lest one be carried too far afield Therefore, only structural patterns which have been found most pleasing to the white American and European stocks will be considered

McCoy (192), in discussing the question of norm, writes· "What standard shall influence us in determining the difference between the anomalous relationships and those to be established? We may examine hundreds of persons who possess . conditions within the range of the normal, and find a large number of dissimilarities among them In other words, a variability will be apparent which will range all the way from mild to extreme differences In computing the normal type, therefore, we are faced with the necessity of calculating the 'mean' from a table of individual values, which may be accomplished by carefully considering essential similarities There is no escape from the use of this helpful principle of normal averages, for the exact ideal normal does not exist On the other hand, anyone who attempts the correction of deformity must have an end in view, i e , the condition which it is desirable to establish, and this must be previously conceived This end to be achieved, therefore, must first be thought of on the basis of the general, or average, characteristics applicable to the race or races from which the patient comes Utilizing such calculating points, the next step then consists in considering each case upon the basis of its individual typal requirements In other words, we compare each case with the norm, based upon normal averages, just as if such a norm existed We know that it does not exist, but is a fiction through the aid of which, by inductive reasoning, we are able to see more clearly the way toward the establishment of the normal in individual cases The real justification for a fiction is its usefulness If it serves the purpose of visualizing a problem in such a manner as to make it comprehensive and intelligible, so that critical judgment may be utilized in considering all factors involved, then it may be considered useful By its help, we must be able to see our way through a problem, at least to the extent of having a definite objective in view toward which we shall strive "

To determine the true character of the deformity in its three dimensions and in its relationship to the balance of the face it is necessary to make the following analyses (1) visual, (2) instrumental, (3) photographic, (4) plaster, and (5) roentgenographic

Visual Examination

Analysis of the nasal deformity may be conveniently begun with a general visual examination

(A) **Profile Observation** It is the profile with its definite lineation which gives the fixed character to every face In order that it may be viewed most advantageously, the patient should be seated squarely in a chair, with his head resting against a head support and the light falling perpendicularly upon him It is especially important that the profile be examined from both sides, because the two halves of the countenance are never exactly symmetrical, and in some individuals they vary to a considerable extent

The nose, as previously stated, consists of three main parts—the bony vault, the upper cartilaginous vault, and the lower cartilaginous vault The nasal profile may be considered normal when no one of these parts protrudes or recedes to a noticeable or exaggerated extent and the nasal profile angle lies between 23 and 37° A straight nose of normal length with a nasal profile angle of 30° is regarded as ideal (fig 272)

The character of the profile is influenced by age At birth and during early infancy

the nose is usually concave, with the tip turned up It becomes straight or convex only in the adult. In old age it has a tendency to become convex, with the tip turned down (fig 273)

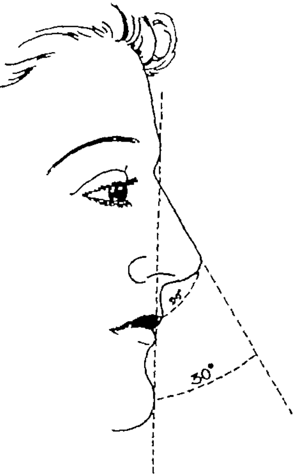


FIG 272. Straight nose of normal length, with nasal profile angle of 30 degrees and nasolabial angle of 90 degrees. Considered ideal.

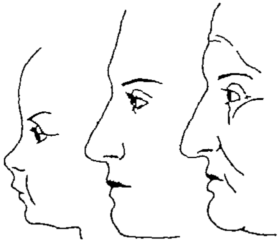


FIG. 273 Influence of age on nasal profile. *a* in infants dorsum concave and tip turned up *b* in adults dorsum straight. *c* in old age, dorsum convex and tip turned down.

The nasal profile offers for examination (1) the root, (2) the dorsum, and (3) the base

(1) *Root* The particular form of the angle at the root of the nose will depend upon the projection of the forehead and the projection and outline of the nasal dorsum The outline of the forehead may be convex, perpendicular, slightly sloping, or greatly receding In the classic Greek type of nose, as seen in the profile of the Venus de Milo, the dorsum forms a straight line with the forehead. A steep forehead with a slightly convex nose and a rather deep depression between the nose and the forehead is characteristic of the Roman type In the profile popularly known as the Greco-Roman the steep forehead with a more or less pronounced depression is combined with a straight nose

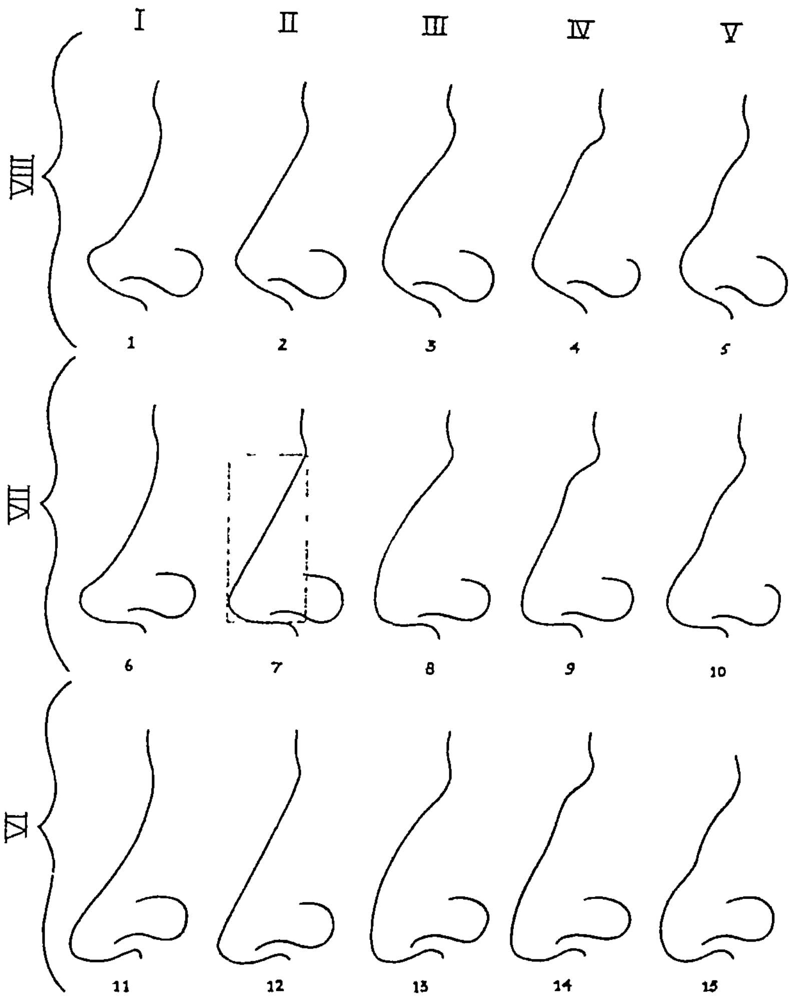


FIG 274 Topinard's classification of noses according to shape of dorsum and inclination of base *I*, concave dorsum *II*, rectilinear dorsum *III*, convex dorsum *IV*, humped nose *V*, undulated dorsum *VIII*, elevated nasal base *VII*, horizontal base *VI*, depressed base

(2) *Dorsum* According to Topinard (309), there are five types of dorsa (fig 274):

(a) *Straight or Rectilinear Dorsum* A straight nose, in which the dorsum forms practically a straight line from root to tip, is considered the ideal type, particularly when encountered in the so-called straight face, in which a straight line drawn from the glabella to the bottom of the chin does not intersect more than a portion of the nose and a very small part of the upper lip A rectilinear nose with a horizontal base and a root only slightly defined, so that the line of the forehead passes gently into that of the nose, constitutes the classic Greek type

(b) *Convex Dorsum.* This type of dorsum describes a uniform convex curve from root to tip The humped dorsum is regarded as a variety of the convex nose It presents a circumscribed convexity, below which the remainder of the dorsum becomes almost straight, the inclination being continued without interception or inflexion into the tip

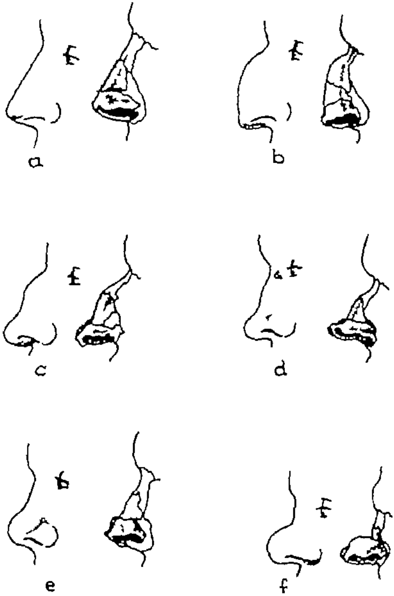


FIG. 275 Structural arrangement of nasal elements in variously shaped noses *a*, straight nose *b* convex nose. *c*, humped nose. *d*, projecting tip *e* retroussé nose. *f* saddle-nose

(c) *High-Bridged Dorsum* In this type the upper bony part presents a strong and short convexity The lower part is nearly straight and is continuous with the ridge of the cartilaginous portion A typical example of this dorsum is the aquiline or Roman nose sometimes considered to be a variation of the convex nose

(d) *Undulated or Sinuous Dorsum* The upper part of this type of nose is convex, but the profile of the lobule, instead of continuing this curve (as in the aquiline or *Roman types*) or of taking a rectilinear direction (as in the humped dorsum), bends inward. The result is that the direction of the line is once more convex toward the tip

(e) *Concave Dorsum* In this type of dorsum the upper part, which corresponds to the nasal bones, descends more or less obliquely in an almost straight line The lower part, corresponding to the lobule, curves outward in such a manner that the entire structure presents in profile a concave shape This outline is usually reflected to form a snub or retroussé nose A concave nose with a reflected tip is often abnormally wide When such a nose is encountered in a concave face, a line drawn from the glabella to the most protruding point of the chin would seem to shut in the features and scarcely touch any of them

Figure 275 shows the structural arrangement in some of the more common types of nasal deformities.

(3) *Base* The most pleasing outline of the base of a nose seen in profile forms an angle of 90° with the line of the upper lip, and as a rule this angle is found in combination with a rectilinear dorsum An angle between 90 and 105° is usually encountered in association with a concave dorsum and is characteristic of the retroussé nose If the angle between the base of the nose and the upper lip is less than 90°, the dorsum is usually convex, and the tip seems to be directed toward the chin (fig 274)

(B) **Full-Face Observation.** The full-face view of the nose is less defined than the profile, and its deviations from the norm are more strictly governed by its relation to other facial features For the first part of this examination the patient should be seated in such a way that his face is illuminated by a light coming partly from the left and a little in front, the right half of the countenance being in shadow The same illumination should be employed for viewing the opposite side of the face

The general width of the entire nose is best observed from a full-face view Broad noses will usually be found to be flattened, but this flattening may also be seen in narrow noses—as, for example, among the Mongols Normally, the width of the nose between the alae should equal the space between the eyes, which in turn should equal the intercanthal length From the nasal root to the junction of the nasal bones with the upper lateral cartilages, there is a slight swelling in the form of an elongated olive, forming what is known as the bridge of the nose This swelling does not show as a protuberance on the dorsum when seen in profile, but when viewed full-face, it is clearly visible and, if very pronounced, gives the nose a special characteristic referred to as a "flat wide bridge"

The full-face view also best demonstrates the width of the tip A thick tip is found in the majority of concave noses, the plane of the nostrils being directed upward, while the fine tip usually accompanies convex noses, the plane of the nostrils being directed downward The tip may appear as a flattened triangular area, owing to the separation of the angles of the lower lateral cartilages Occasionally, a bilobed cleft is seen, the angles forming distinct ridges under the skin

The alae or wings of the nose may be delicate, puffy, round, flat, triangular, square, or almost almond-shaped Their normal height is one quarter the distance from the tip of the nose to a point midway between the eybrows

The external aspect of the nose has been aptly described by Hatton (98) as follows (fig 276-I) "The central cartilage of the end (medial crura of lower lateral cartilage) (a), proceeds further down than the side cartilages (lateral crura)—the wings, (b) The wings are in form between the circular and the angular There is always a degree of angularity about them, but they are sometimes nearer the round and sometimes nearer the square . Both the central cartilage (a) and the wings

(b) curl up into the nostril From the wing there passes a buttress, (c), over the nostril to one bulb of the tip (d) This buttress is less voluminous than either the wings or the tip, which stand up a little above it. Further the buttress is hollowed above. The tip consists of two symmetrical bulbs (d) and (e), between which there is generally a slight depression. From the tip the column (dorsum) starts upward, first being somewhat rounded at (f), then flatter wider, and bony at (g), next thinner and rounder again at (h) The roundness continues till it reaches a slight hollow (l), which is observable in the skeleton The side of the nose, (j), is hard and bony, being built upon a plate of the superior maxillary This surface is not flat but slightly depressed at all its borders and thus becoming similar, in bulging to one side of an almond The nose of a woman is narrow and less boldly modeled than a man's There is less width across at j j and less across the wings at b-b, and hence its walls are more pre-

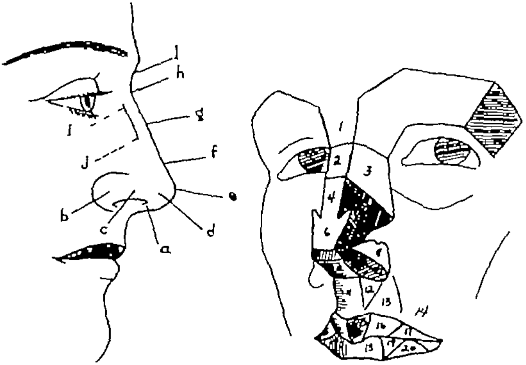


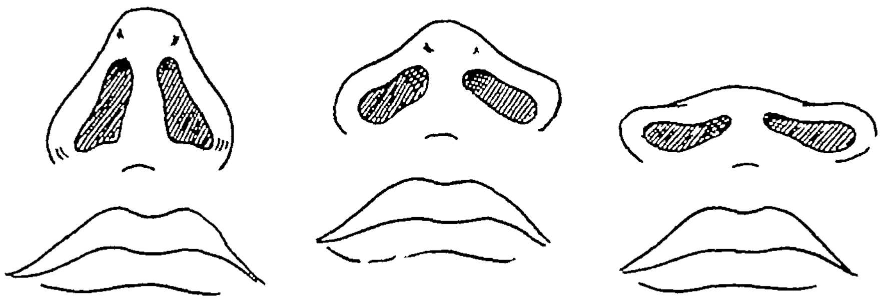
Fig 276 Topography of nose. For details see text. (Hatton)

cipitous. The modelling of the wing and tip are also much less forcible than a man's and the nostrils have not the same appearance of dilation but look pinched. "

The nose may also be studied as a series of wedges or planes, as demonstrated in Figure 276-II Where the upper bony bridge wedges in under the forehead the two ridges of the glabella descend to form a wedge with its apex at the bridge (1 and 2) The bony part of the nose is a very clear wedge (2) its ridge less than one-half the length of the dorsum. As its descends it becomes higher and its base is somewhat longer and wider, forming the second wedge (3) Beyond the bony part the nose narrows toward the tip making a fourth wedge base to base with (2) The ridge that separates (2) and (3) from (4) and (5) outlines the limit of the bone. The columella (10) rises as two sheets of cartilage from the middle of the upper lip expands into a bulbous tip (6), flows over the sides (7), and flares out to form the alae or wings of the nostrils. This cartilaginous portion is quite movable. (8) is the sloping "roof"

of the side of the tip and embraces the wing part of the tip (9) is a plane about at right angles with (8) The septal cartilage is (10), forming the lowest part of the nose, and is convex downward (12) is the plane which connects the lip with the tip of the nose. (13) and (14) represent the fulness of the lip (15 to 20) represent various planes of the vermilion border

(C) **Basal Observation.** The base of the nose can be best observed if the patient's head is tilted backward as far as possible From this aspect the shape of the nostrils is clearly outlined. They range from mere slits to voluminous openings, varying with race, heredity, trauma, disease, and individual characteristics. In individuals of the white race the nostrils are elliptical from above downward, while in the members of negroid races they are transverse or nearly round Figure 277 shows the direction they tend to assume in the various races.



a b c

FIG 277 Basal view, showing direction of nostrils in various races *a*, vertical, seen in leptorhines. *b*, oblique, seen in mesorhines *c*, horizontal, seen in platyrrhines

Instrumental Examination

A visual examination yields only a general idea of the nasal deformity For a more detailed analysis of the character of the deviation an instrumental examination is necessary

(A) **Rhinometer.** The author has devised a special sterilizable instrument, the rhinometer (figs 278–280), embodying the combined features of calipers, slide compass, tape measure, and goniometer. In addition to being useful in the diagnosis of nasal deformities, it is also of value for the progressive checking of the results of nasal operations, and for the compilation of data for statistical purposes The instrument consists of the following parts. (a) *A hollow vertical column*, designed to carry horizontal cross-members, and with a vertical slit on one side for the accommodation of sliding cross-member carriages The column has a numerical scale marked on its surface for the taking of measurements between cross-members in a vertical direction (b) *Cross-member carriages*, designed to hold horizontal cross-members at various levels along the column, and to provide for horizontal displacement of the cross-member by a sliding motion of the members within their respective carriages. Each carriage is connected, through the slit in the side of the column, with friction surfaces inside the hollow of the column The position along the column of any carriage and its cross-members may be changed simply by a pressing in on the carriage toward the column, this motion disengaging the friction surfaces and sliding the carriage to the desired level Release of pressure automatically locks the carriage at the position. The upper surface of each carriage is open and is provided with a pointer which permits

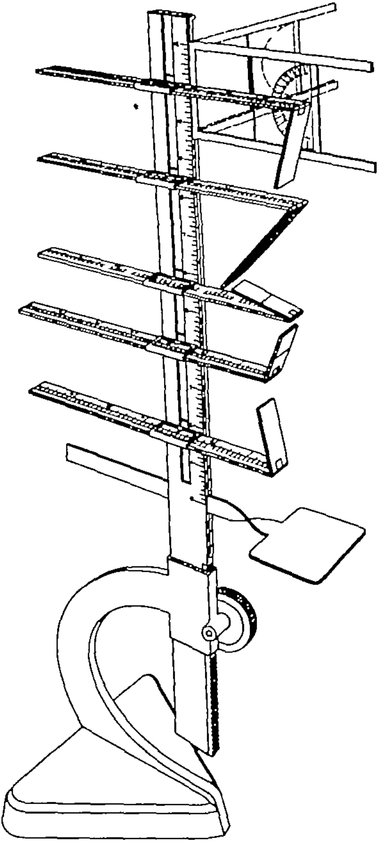


FIG. 278. Rhinometer combining features of calipers, slide compass, tape measure, and goniometer employed for diagnosis of nasal deformities and checking results of operations. For details, see text.

of the taking of readings on the scale of the horizontal cross-member (c) *Horizontal cross-members*, slidably held within the cross-member carriages, for carrying end-flaps,

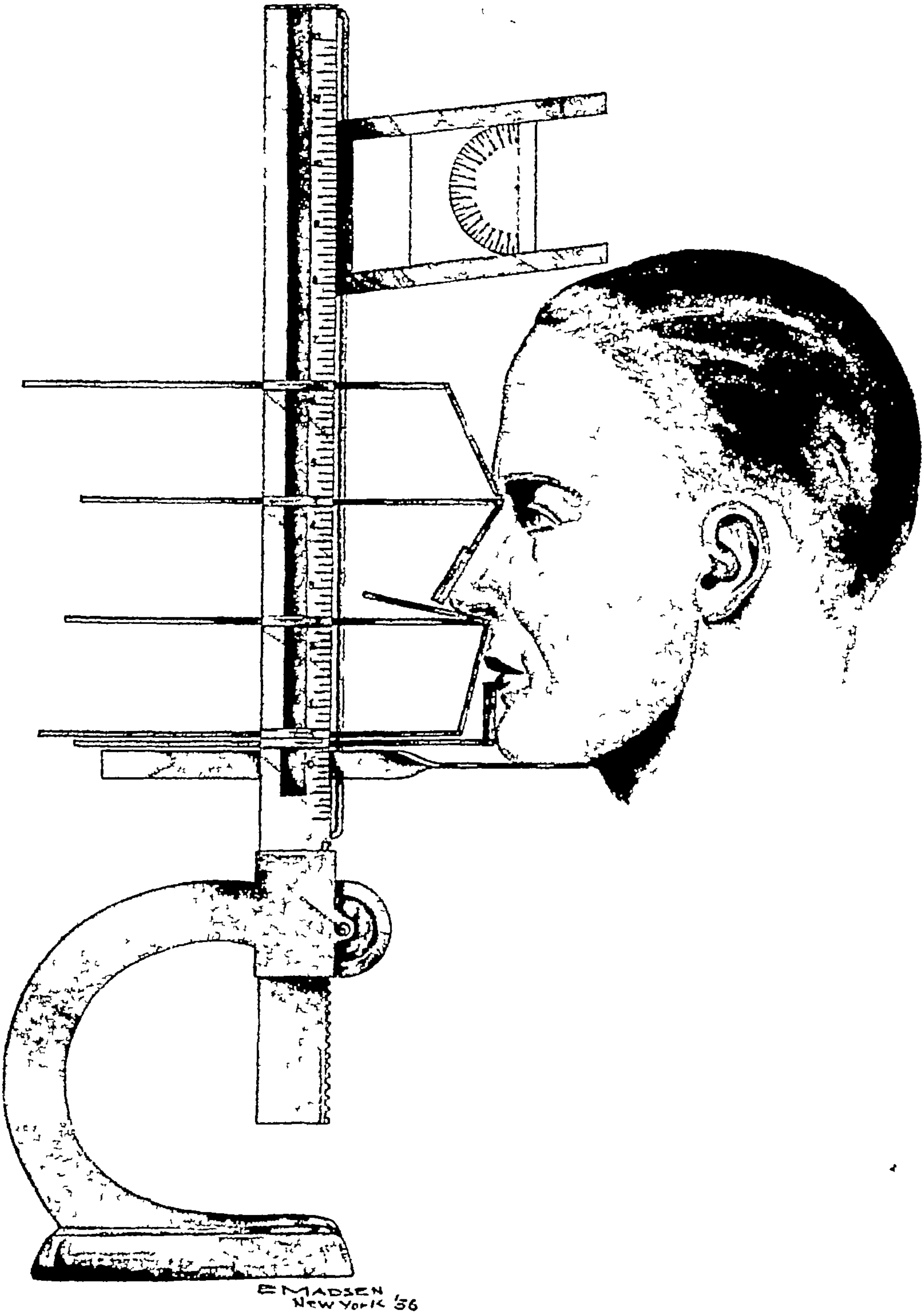


FIG 279 Application of rhinometer

and with a scale marked on their surface for measuring the horizontal disposition of profile landmarks in relation to a vertical reference line (d) *End-flaps*, connected to one extremity of each cross-member by means of friction hinges and designed to

record the relation to the vertical of the various planes of the profile. Two of the end-flaps are hinged in the middle so that they may be folded in half for the accommodation of a wide range of profile sizes without interference of the parts. (e) *A chin rest* in the lower part of the column for the support of the patient's chin. Although adjustable along a horizontal plane for the individual's comfort, its position in the

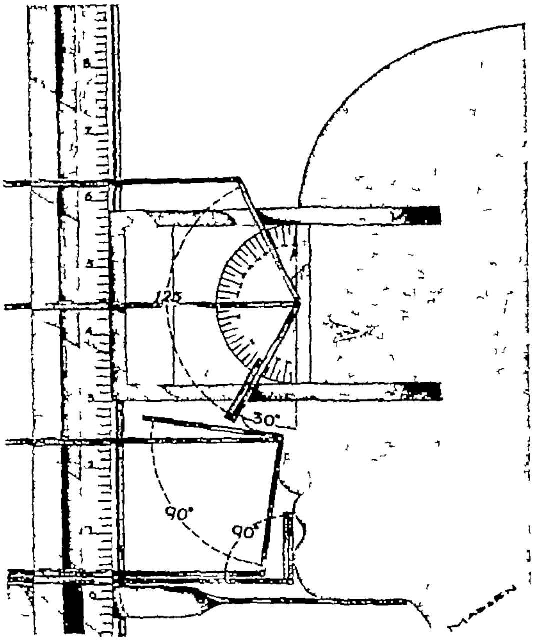


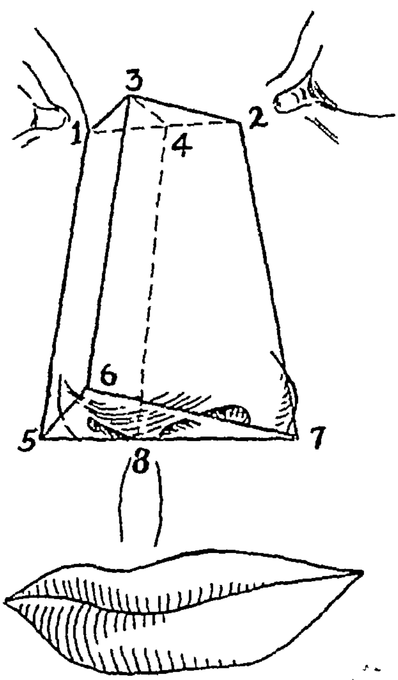
FIG 280 Protractor of rhinometer brought to bear against cross-members, for purpose of measuring relationships

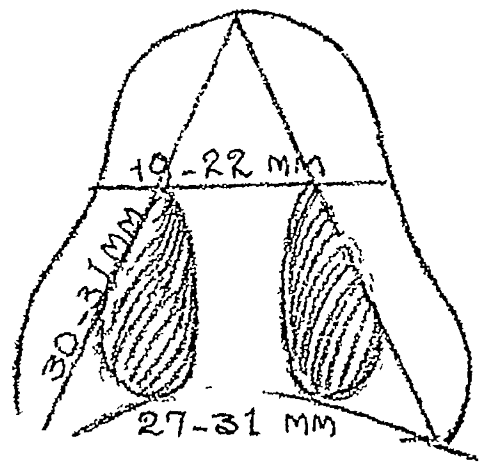
longitudinal axis of the column is fixed hence it acts as a starting point for all measurements taken in the vertical position. (f) *A cantilever-type support and base,* designed to hold the vertical column at its lower extremity and to permit of its adjustment in a vertical direction by means of a rack and pinion mechanism (g) *A protractor carriage,* slidingly carried on a vertical rod affixed to the column. The carriage in turn contains the protractor which slides along the carriage in a horizontal direction. By this

arrangement the protractor may be brought to bear against any of the end-flaps for the purpose of measuring their relation to the vertical

(B) **Absolute Measurements.** The following absolute measurements when taken singly are of little practical value, but when calculated in various combinations, they help to establish the "fictional ideal" for purposes of comparison

(1) *Linear Measurements of Nose, Face, and Head* (figs 281–284) The *length of the nose* is represented by a line drawn from root to tip and ranges, within normal limits, between 42 and 60 mm , the average being 55 mm The *height of the nose* corresponds to a line extending from the central point of the root to the subnasal point and averages 51 mm. This measurement is extremely important in calculating the proportion of the nose to the face, as will be seen later The *breadth of the nose* is the distance between the alae at the points of widest expansion It varies between 25 and 38 mm , the





line to chin) with an average of 176 mm. From the root of the nose to the chin it ranges between 111 and 122 mm. The *breadth of the face* between the two zygomata in the male varies from 127 to 152 mm., averaging 140 mm., in the female from 120 to 146 mm., averaging 129 mm. The breadth between the mandibular angles varies from 84 to 108 mm., the average being 103 mm. The *depth of the face* between the auricle and the nasion is 100 mm. (auriculonasion depth), between the auricle and the menton 119 mm. (auriculomenton), and the goniomenton depth is 98 mm. The *length of the head* from the glabella to the most prominent part of the occiput ranges between 173 and 202 mm., the average being 187 mm. The *breadth of the head* is represented by a line drawn between the external acoustic meati and ranges between 137 and 157 mm., averaging 145 mm. This measurement, correlated with the length of the head, is helpful in the determination of the general type of head and its relation to the face and nose (fig 285)

(2) *Angular Measurements* Angles of the face are measured either directly on the individual or indirectly by means of photographs and casts. Whatever method is used, it is essential for the sake of consistency that the head be placed in a fixed horizontal position The *Frankfort horizontal plane* has come to be accepted as a standard. It is an imaginary plane lying upon four points, the two higher points being in the margin of the auditory meatus, and the two lower on the orbital margin.

The *frontal profile angle* indicates the slope of the forehead. It shows the inclination of the nasion metopion line to the Frankfort horizontal plane. The *nasal profile angle* indicates the degree of projection of the nose from the face. The normal range is between 23 and 38° the ideal angle being 30° The *nasolabial angle* is located between the base of the nose and the upper lip, with its apex at the subnasal point. It indicates the inclination of the base of the nose, the average being 90° The *frontonasal angle* is the obtuse angle formed between the root of the nose and the forehead. If this angle is non-existent, the dorsum forms a straight line with the forehead, and the Greek type of nose is produced.

(C) **Relative Measurements.** (1) *Indices* The relative measurements employed in rhinometric analysis are termed indices. Their purpose is to establish a basis of comparison for the computation of correct relationships between the component parts of individual noses in faces of different general sizes and shapes.

The index of a given measurement is its percentage in reference to some other measurement which is fixed as the equivalent of 100 It is thus a relative and not an absolute term, and may be compared directly with the corresponding index in another individual of different size, or to a head face, or nose of different general size which requires similar proportions to those of the fixed or "average" model. For example, given three noses—one, which is long and narrow the width equalling exactly ½ the length another in which the width is ¾ the length, a third, in which the width and length are equal. Now if the total lengths are exactly the same in all three cases—for instance, 60 mm.—the three breadths would be respectively 30, 45, and 60, and they could be directly compared. If, however, the lengths were not alike, direct comparison would be impossible without the use of an index. Thus the use of an index permits us to say that in the first nose the breadth is 50 per cent of the length, in the second 75 per cent, and in the third 100 per cent, and these proportions can be compared directly, whereas the actual measurements in millimeters cannot. The indices, therefore, are the proportions of the breadths to the lengths. Whatever the actual

lengths, they are considered to equal 100 in all cases, and the breadths are expressed as so many parts of that 100 This is represented by the formula: $\frac{\text{breadth} \times 100}{\text{length}} =$ index

For the proper estimation of the nasal deformity comparisons with the face and cranium are essential Such comparisons require calculations of the following indices. (1) the nasal, (2) the facial, and (3) the cephalic Since no two crania or faces are

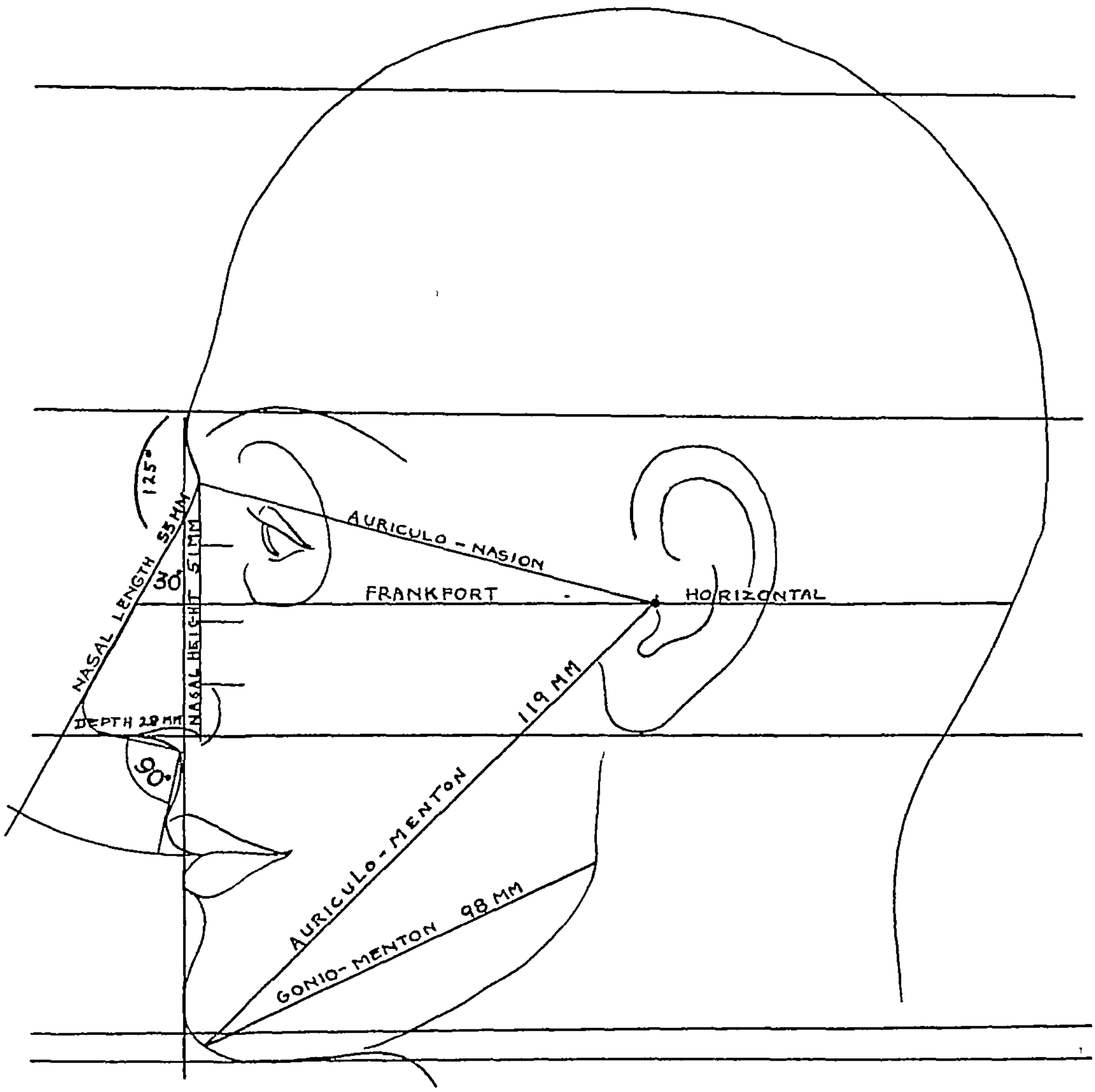


FIG 282 Linear dimensions of face Profile view For details, see text (Schadow)

exactly alike in size or shape, it is logical to assume that the nose will vary in relative proportions In order that the size of the nose may be standardized for purposes of accurate comparison, the nasal index must be calculated If the nasal, facial, and cephalic indices are each found to be within normal limits, the shape of the nose, face, and cranium are within the laws of harmonious relation

(a) *Nasal Index* The nasal index indicates the form of the nose It is obtained by multiplying the breadth of the nose by 100 and dividing the product by the height This index varies in the proportion of 1 to 3 (from 40 to 120), according to the race of the individual Thus, among the platyrrhines (characterized by broad noses and

nostrils) the normal index exceeds 85, among the leptorhines (distinguished by narrow noses and nostrils) it is below 70, and among the mesorhines it is between 70 and 85 The negro races are platyrrhines with broad, flat noses, the yellow races are mesorhines with medium noses, whereas the white races are the opposite extremes, the leptorhines, with deep, prominent and narrow noses. As a rule, the more prominent the nose, the narrower, and the more depressed, the broader A normal nasal index merely indicates that the relation of the width to the length is proportionate, but in order

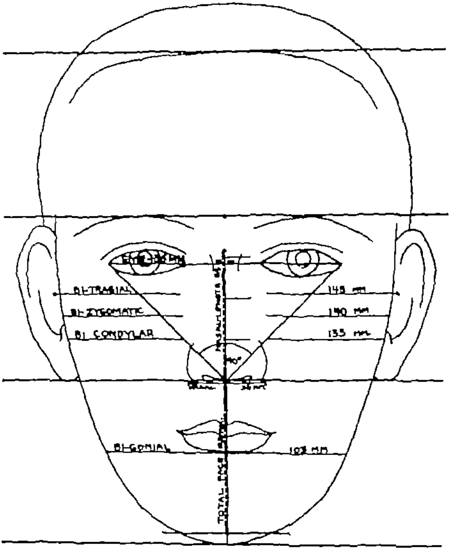


Fig 283 Linear dimensions of face. Frontal view For details, see text. (Schadow)

to determine whether this proportion is in harmony with the face, other indices must be obtained.

(b) *Facial Index.* The facial index is used to express the form of the face and is obtained by multiplying the maximum breadth by 100 and dividing the product by the morphologic height, which is the distance between the hair line and the lowest point of the chin. Thus, $\frac{\text{maximum breadth of face} \times 100}{\text{morphologic height}}$ = male, 73 to 98, averaging 86, and female, 67 to 86, averaging 85 The "physiologic' index is the same, except that the divisor is the distance between the root of the nose and the lower part of the

of the glabella and the horizontal line through the nasolabial angle When the head has been thus positioned, it is immobilized by means of a head-clamp attached to the chair. To analyze the deformity to the best advantage, the completed photograph is divided into a number of areas by lines drawn between given points The features are framed within these lines with a view to calculating the proportion of the facial parts one to another, as described on page 655

To obviate the necessity of drawing lines on the photograph, the patient may be placed in back of a screen provided with markings similar to those on the lens, and the picture taken through it The screen is supplied with movable rods which are adjusted to coincide with the lines on the ground glass of the camera Thus one rod is placed vertically on a line bisecting the glabella and the other horizontally across the nasolabial angle The screen is accurately spaced at 1-cm intervals horizontally and vertically, so that all the squares will be 1 cm in length and width By adding together the number of squares covering any given area and calling them centimeters the exact measurement is obtained For instance, suppose the length of the nose is covered by 6 squares and the width of the base by 3 squares, the length would be computed as 6 cm and the width as 3 cm. After the nose has been corrected, another photograph is taken through the same screen under exactly similar conditions Suppose the length of the nose is now covered by 5 squares, and the width by $2\frac{1}{2}$ squares This will indicate that the length of the nose has been reduced by 1 square or 1 cm, and the width by $\frac{1}{2}$ square or $\frac{1}{2}$ cm If more detailed dimensions are required, each square may be calibrated to show fractions of a centimeter. Photographs are filed with other hospital records, and the differences in measurements are noted on the record sheet

According to McCoy (192), Simon has evolved a definite technic for photographing patients—the "photostatic method"—which provides a degree of accuracy not attainable by other methods, making it possible to obtain photographs in a manner so that all are projected in the same relationship (fig 286). These photographs not only provide for analysis of the facial lines and proportions but allow all subsequent photographs of patients previously taken to be reproduced under the same conditions All photographs are taken $\frac{1}{2}$ life size, subsequent pictures being made under the same conditions with the head always the same distance from the camera The apparatus is so arranged that the line of the lens axis passes through the lower edge of the orbit just below the pupil Simon employs a camera attached to a solid adjustable stand, and from this stand is extended a beam, the end of which carries a nose board The patient is seated in a chair with the head supported, the nose board is affixed so that its lower edge is in contact with the lower margins of the orbit. When this relationship has been established and the median plane of the head placed parallel to the plate or film, the patient is instructed not to move, the nose board is removed, and the exposure made. A background of black felt cloth is employed The source of light comes obliquely from in front of and above the patient. A $\frac{1}{2}$-watt lamp 100 to 300 candle power in a suitable reflector serves the purpose. These lamps are held in brackets and are always made to occupy the same relationship to the patient being photographed To avoid glare, the face of the reflector is covered with a transparent substance

Charting of Face. When viewing a face or its reproduction in a photograph or cast, one unconsciously balances the relation of its individual elements and compares them with a mental standard. Various such standards of proportion have been formulated and charted by Vitruvius, Michelangelo, Leonardo da Vinci, Albrecht Dürer, Quetelet,

Seggel, Richer, Stratz, Schadow, and others While these criteria cannot be slavishly followed, they are valuable in that they express a relationship from which there cannot be more than a very slight deviation without a transgression of the laws of harmony The relationship of the facial elements is best expressed by dividing the face with the aid of imaginary lines The surgical value of such divisions is (1) to analyze asymmetry between the nasal elements, (2) to show the relation of the nose to adjacent facial elements, (3) to compare postoperative results with the original deformity and (4) to serve instructional and statistical purposes.

(1) *Full Face Division* (fig 287) A vertical line is drawn from the middle of the forehead to the middle of the chin and each facial half is further subdivided into 5 equal spaces by 4 vertical lines on either side of the central line. In a face of ideal proportions 1 space is occupied by half the width of the nose, 2 spaces are filled by the

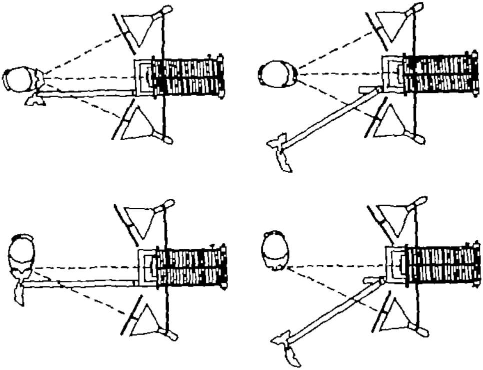


FIG 286 Principles involved in use of Simon's photostatic clinical camera. For details see text. (McCoy)

width of the eye and 2 spaces comprise the area from the corner of the eye to the front of the ear

If horizontal lines are drawn through the eyebrows and above and below the eye, it will be noted that the distance from the eyebrow to the upper lid is equal to the distance from the upper lid to the lower lid and that each space equals ⅓ the horizontal width of the eye.

If additional horizontal lines are now drawn through the base of the nose the opening of the mouth, and the depression below the lower lip, it will be seen that the distance from the base of the nose to the opening of the mouth is equal to that from the opening of the mouth to the depression below the lower lip It will also be found that lines through the upper lid and the base of the nose enclose both the nose and ears, which are of equal height. Another observation is that the lines drawn between the outer corners of the eyes and the tip of the nose form a right angle. Furthermore a horizontal

line between the temples will be equal in length to the vertical line from the root of the nose to the end of the chin

As previously stated, faces need not be similar to fulfil the *requirements* of proportion As can be seen in Figure 287-b, all that is necessary is that two of the smaller spaces appear alike, and that they vary sufficiently in size from the wider spaces not to suggest likeness where it should not exist The face is partitioned into 6 spaces by means of horizontal lines as follows: Parallel lines are drawn through the lowermost part of the chin, the opening of the mouth, base of the nose, middle of the eye, eyebrows, hair line, and coronal suture The face is thus divided into 6 horizontal regions It will be noticed that the narrow spaces, 1, 3, and 5, alternate with the wide ones, 2, 4, and 6, in the ratio of 1 to 2

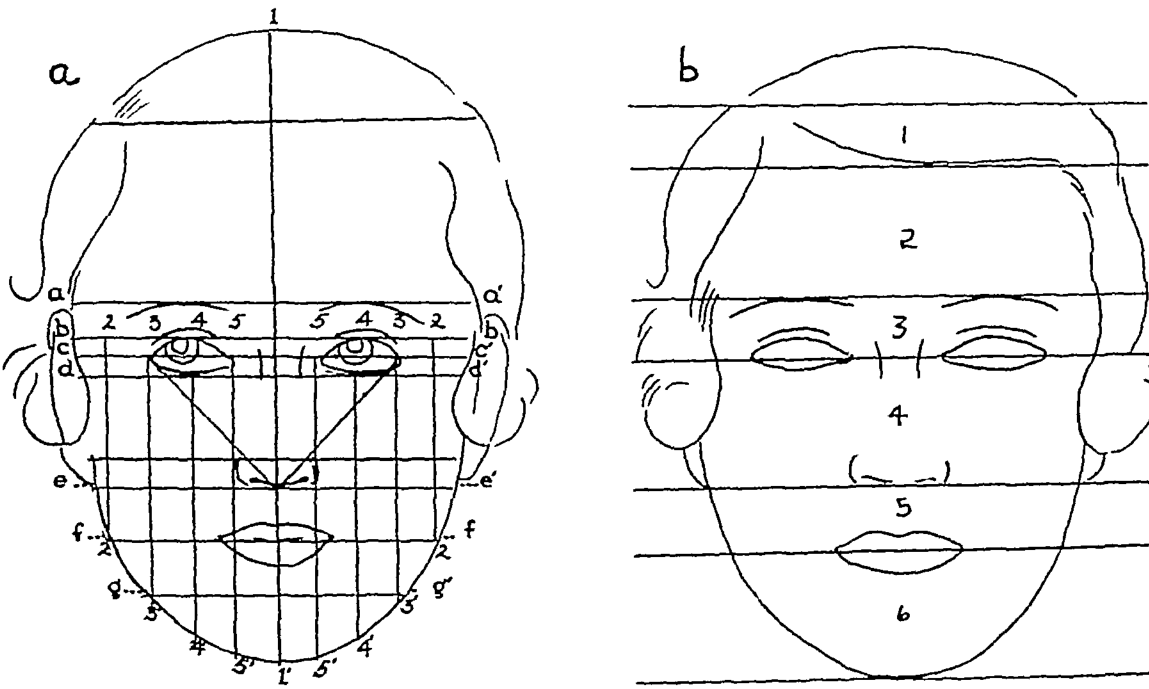


FIG 287 Photographic charting of face *a*, face divided by horizontal and vertical lines *b*, face partitioned into six spaces, narrow ones 1, 3, and 5 (of equal size) alternating with wide ones, 2, 4, and 6 (of equal size) in ratio of 1 to 2 For details, see text

Similarly, the face may be divided into 4 parts by means of horizontal lines as follows (1) through the lower part of the chin, (2) through the base of the nose, (3) through the level of the eyebrows, (4) across the hair line, and (5) through the vertex According to generally accepted rules, in a face with "regular" features the first 3 spaces thus formed are of the same height If at least the first 2 parts are approximately equal, the face will still appear fairly regular, even if the hair line varies If the second division, which includes the nose, eyes, and ears, be further subdivided with the following lines, the spaces thus formed should equal one another (1) across the upper margins of the alae, (2) through the junction of the nasal bones and the upper lateral cartilages, and (3) through the axes of the eyes

Schadow (272) divided the face from the eyebrows to the chin into 6 horizontal parts of equal width (fig 288). In the ideal face, according to his canon, 3 of these spaces should be occupied by the nose, 1 space by the upper lip, and the 2 remaining by the lower lip and chin Thus, the nose forms about ½ the length of the face, if the forehead

is excluded Other comparisons of the facial elements shown in the diagram are as follows The lower edge of the upper eyelid lies on a level with the upper edge of the auricle. The base of the nose is on a slightly higher level than the lower border of the lobule of the ear

(2) *Profile Division* In profile view the following geometric relations have been formulated Lines drawn from the root of the nose to the end of the chin, from the root of the nose to the antitragus, and from this point of the ear to the end of the chin, will form in a "regular" face a more or less equilateral triangle. The distance from the outer canthus to the front of the ear is the same as that from the outer canthus to the

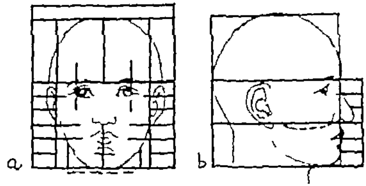


FIG. 288 Schadow's division of face. *a*, frontal view *b* lateral view For details, see text

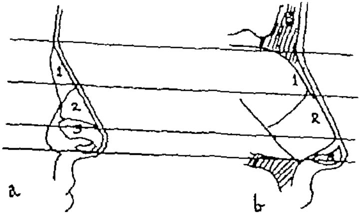


FIG. 289 Anatomic profile components of nose. *1* nasal bones *2* upper lateral cartilage and septum. *3* lower lateral cartilage. (Joseph)

corner of the mouth. This applies particularly to the heads of women, in men the ear lies a little more posteriorly The height of the alae is ½ the distance from the tip of the nose to a point midway between the eyebrows (fig 282) The lines from the gnathion to the gonion and from the gonion to the tragion are of equal length The mandibular angle varies from 130 to 140°

Joseph divided the nasal profile into 3 structural components as shown in Figure 289 The first extends from the nasal root to the lower border of the nasal bones, the second comprises the upper lateral cartilages and cartilaginous septum, and the third consists of the lower lateral cartilages. Using this scheme as a standard, one is enabled to analyze specifically any type of profile deformity (fig 290)

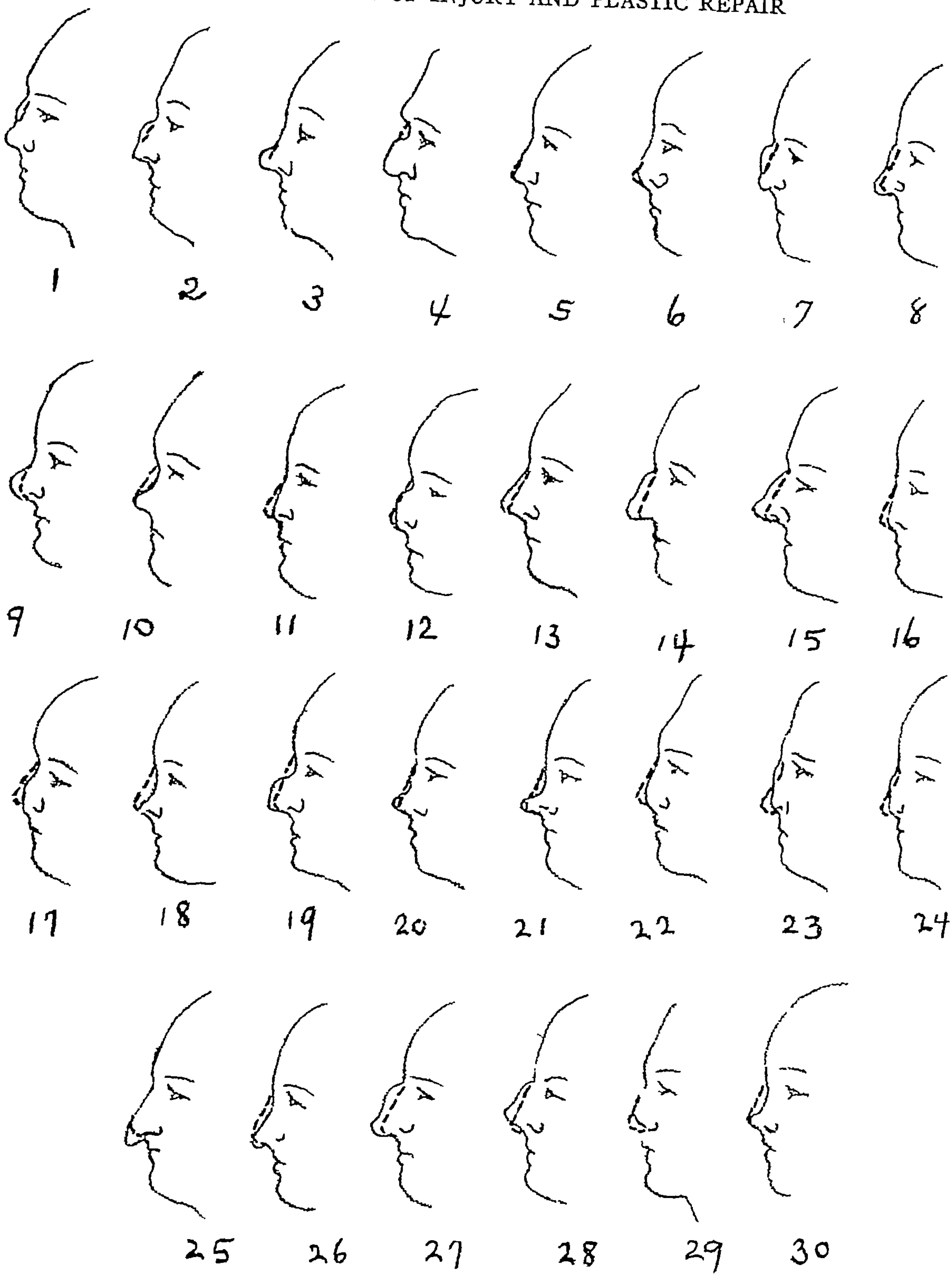


FIG 290 Abnormal nasal profiles, classified according to 3 structural components *1*, upper component projecting *2*, middle component projecting *3*, lower component projecting *4*, upper component receding *5*, middle component receding *6*, lower component receding *7–9*, two components projecting *10–12*, two components receding *13–15*, all components projecting *16–18*, all components receding *19–24*, components partly projecting, partly receding *25–27*, all components too long *28–30*, all components too short (Joseph)

Cast Analysis

Casts are superior to photographs, since they offer a 3-dimensional record, thereby accurately duplicating the original both in form and size As working models they

are indispensable in the planning of the contemplated operative procedure. Their value in this respect is well illustrated in the case of a saddle nose with a projection angle of less than 23° A cast of the defective face is made in plaster, and the dorsal depression is built out in wax, so that the profile angle equals 30° The wax model represents the approximate size of the transplant to be employed to secure the necessary dorsal elevation. If the wax model is then cast in some sterilizable material, it may be used as a pattern for shaping the graft at the time of operation, thus obviating the necessity of multiple insertions and lessening the danger of infection The details for the construction of casts are given in Chapter XX.

Radiographic Analysis

A well-developed roentgenogram is of great value in the interpretation of the pathologic factors involved in certain nasal deformities Its use will be discussed in the appropriate sections.

NASAL DEFORMITIES WITHOUT LOSS OF TISSUE

The aim of nasal reconstruction is to achieve structural balance and at the same time bring about functional efficiency The most perfect anatomic repair which has failed to restore function is displeasing and disturbing, and creates a feeling of abnormality probably because ideals of form are unconsciously based upon normal function. Therefore before any reconstructive operation is attempted, all pathologic processes within the nose should be eliminated

The first surgeon to attempt an operation for this type of nasal deformity was Dieffenbach (45) (1845), who reduced the size of an abnormally large nose through an external incision, but it was not until the intranasal incision was introduced by Roe (258) (1887) that the operation became popular Credit for standardization of the technic must be given to Weir (330) (1892), Joseph (133) (1898), Goodale (84) (1899), Hoffa (107) (1900) Clark (1901), and Lexer (169) (1905)

Classification of Deformities

No classification can embrace the obviously infinite varieties of nasal deformities, but if a clear conception of the basic underlying types, as outlined below, is obtained any combination of disfigurements can readily be analyzed.

(A) *Deformities of Bony Vault*
- (1) *Root*
  - a Wide upper nose—caused by exostoses and hypertrophies of nasal bones and frontal processes of maxillae
  - b Narrow upper nose—caused by atrophy or underdevelopment of frontonasomaxillary region
- (2) *Bridge*
  - a Hump nose (abnormal convexity)—caused by exostoses or hypertrophies of nasal bones
  - b. Saddle nose (abnormal concavity)—caused by atrophy or depression of nasal bones

(3) *Lateral Walls*
- a Lateral hump—caused by osteophytes or hypertrophies of nasal wall
- b Deflected nose—due to angulation or deviation of nasal bones

(B) *Deformities of Upper Cartilaginous Vault*
(1) Long nose—due to abnormal length of upper lateral cartilages or septum
(2) Short nose—due to shortening of upper lateral cartilages or septum
(3) Wide cartilaginous nose—due to abnormal curvatures of upper lateral cartilages
(4) Septal deformities

(C) *Deformities of Lower Cartilaginous Vault*
(1) Angle
- a Wide tip—due to excessively wide angles of lower lateral cartilages
- b Narrow tip—due to excessively narrow angles of lower lateral cartilages
- c Cleft tip—due to separation of angles of lower lateral cartilages
- d Twisted tip—due to hypertrophy, buckling, or overlapping of one angle
- e Hook nose—due to increased vertical length of angles, with downward displacement
- f Retroussé tip—due to decreased vertical length of angles, with upward tilting
- g Prominent tip—due to abnormal length of lower lateral cartilages in anteroposterior direction
- h Flat tip—due to shortening of lower lateral cartilages in anteroposterior direction

(2) *Medial Wall (Columella)*
- a Lengthened columella
- b Shortened columella
- c Widened columella
- d Narrowed columella
- e Thickened columella
- f Oblique columella
- g Retracted columella
- h Hanging septum (increased width of mesial crura of lower lateral cartilages)
- i Projecting septal cartilage

(3) *Lateral Walls (Alae)*

As to curvature
- a Abnormally convex alae
- b Abnormally concave alae
- c Flat alae

As to dimensions
- a Abnormally long alae
- b Abnormally short alae

As to position
- a Elevated alae
- b Depressed alae
- c Asymmetrical alae

As to width
- a Thick alae at apex or base
- b Thin alae at apex or base

(D) *Deformities of Nostrils*

Since the nostrils are bounded by the alae, columella, tip, and base of the nose, any malformation of these structures must result in one or more of the following deformities

a Long nostril
b Short nostril
c. Wide nostril
d. Narrow nostril
e. Asymmetrical nostril
f Flaring nostril
g Collapsed nostril

Sequence of Operative Steps in Typical Corrective Rhinoplasty

Nasal deformities, as a rule, affect more than one element of the nasal framework, and even in those rare instances in which an isolated deformity occurs, its correction necessarily creates secondary disturbances which demand additional reconstruction. For instance, the removal of a hump in an otherwise normal nose immediately causes a relative increase in the width and length of the nasal pyramid and throws the alae out of proportion.

Satisfactory results will depend as much upon the sequence of the operative steps as upon the care with which each step is carried out For example, given a typical deformity, such as a long nose with a hump and a wide tip, the consecutive steps should be as follows (1) removal of the hump, (2) shortening of the nose, (3) narrowing of the arch, and (4) narrowing of the tip Failure to observe this sequence is apt to create many unnecessary difficulties. Only by a removal of the hump can the proper shortening be attained, since this correction apparently increases the length of the already long nose Were the sequence of the first and second steps reversed, it would be found after removal of the hump that the previous shortening had been inadequate. The third step consists in the narrowing of the arch, since the proportion of the lobule to the balance of the nose can be ascertained only after the nose has been reduced to its proper dimensions. To present adequately the operative technic involved in the correction of the individual deformities, then, it seems advisable to describe first a typical operation, even though this necessitates a certain amount of repetition The correction of a long nose with a hump and a wide tip will be used as an example

Instruments

Only the basic instruments employed for the procedure are listed here Special instruments will be mentioned in the sections dealing with specific operations. The general set includes the following (fig 291) Speculum pronged retractor, scalpels (Bard Parker knife #11, double-edged knife curved on the flat, button-end knife angulated knife) periosteal elevators Joseph's right and left bayonet saws, Joseph's right and left right-angled saws, small chisel and mallet, scissors (straight, curved, and double-edged), nasal rasps, tissue forceps, Walsham's forceps, mosquito hemostat forceps dural hooks needles, silk, needle holder, Record syringe with needles of various sizes, stent s modeling compound.

Preoperative Measures

While it is true that the nose is tolerant to infection, it is also true that when infection does occur, it is fraught with serious consequences (p 978) Therefore, aseptic principles must be meticulously observed in the preparation of the operative field. The

general preparatory measures essential to an ultimate uncomplicated recovery—namely, estimation of the surgical risk and adequate preliminary sedation—do not differ from

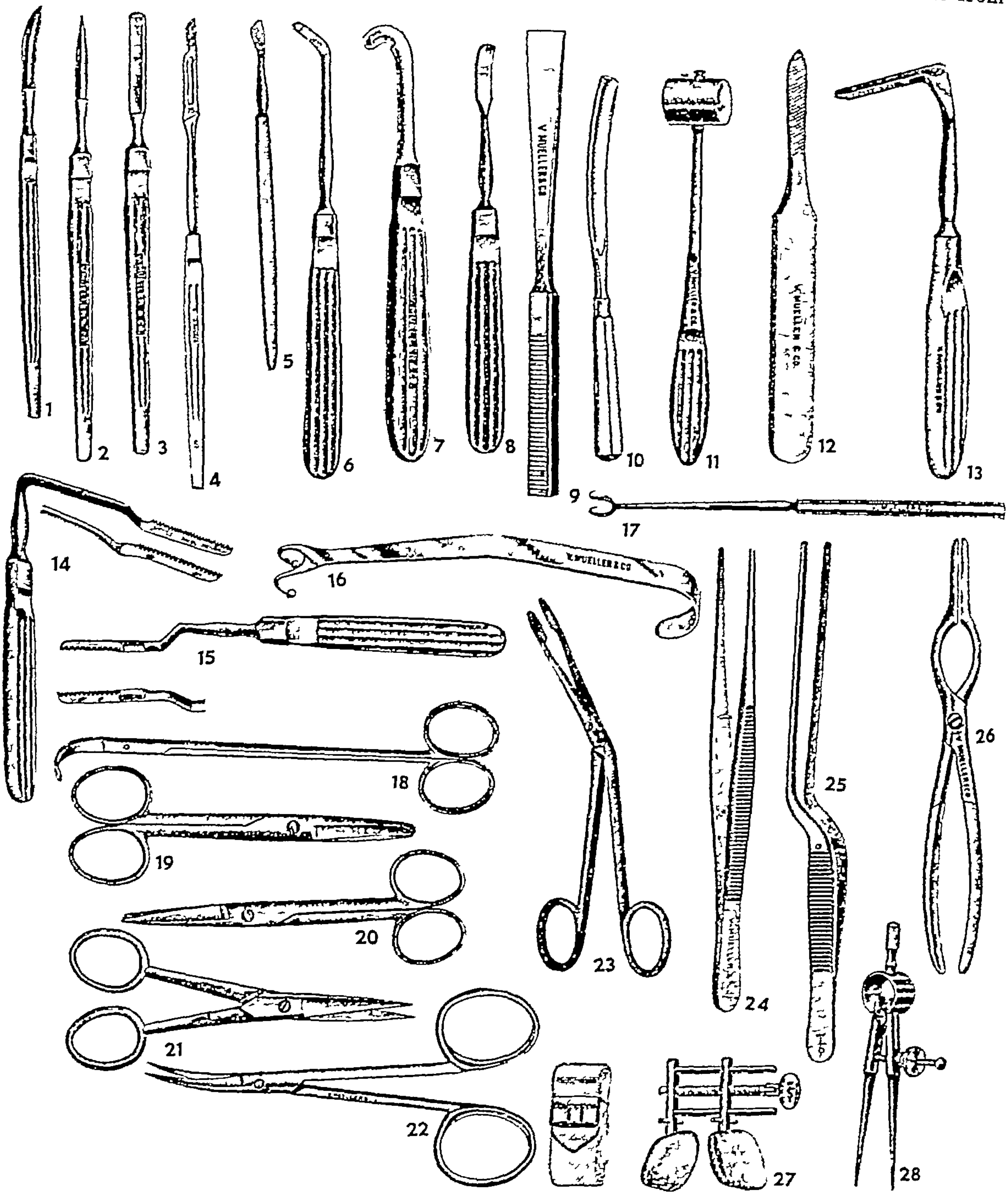


FIG 291 Instrumentarium for rhinoplastic operation *1*, double-edged curved knife *2*, double-edged straight knife *3*, button-end knife (Joseph) *4*, Bard Parker knife #15 *5*, septum knife *6*, angulated cartilage knife *7*, sickel knife *8*, periosteal elevator (Joseph) *9*, bone chisel *10*, gouge chisel (Kelly) *11*, mallet *12*, rasp *13*, nasal speculum (Aufricht) *14*, right and left right-angled saws *15*, right and left bayonet saws *16*, nasal retractor *17*, two-pronged retractor *18*, cartilage scissors (Joseph) *19*, small Mayo scissors *20*, blunt-pointed scissors *21*, sharp-pointed scissors *22*, curved sharp-pointed scissors *23*, nasal forceps *24*, tissue forceps *25*, bayonet forceps *26*, Asch forceps *27*, nasal splint (Joseph) *28*, calipers

those employed in surgery on other parts of the body For details the reader is referred to Chapters VII and VIII

The special procedures to be adopted include *preparation of the field of operation, draping*, and *anesthesia*

Preparation of Field and Draping The local preparation of the nose is begun about 45 minutes before the time scheduled for operation The vibrissae are clipped with a pair of fine-pointed scissors, care being taken to avoid puncturing the lining (fig 292 (1))

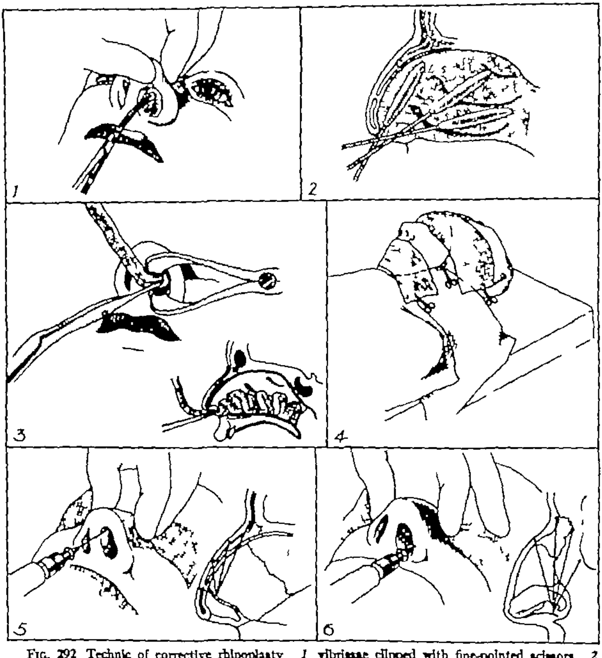


FIG. 292 Technic of corrective rhinoplasty *1* vibrissae clipped with fine-pointed scissors *2*, nasal mucous membrane anesthetized by direct blocking of sensory nerves. *3* strip of gauze introduced into each nostril, to prevent escape of blood into nasopharynx. *4* head draped with towel, and eyes and mouth covered with gauze. *5–6* anesthetic solution introduced into nasal pyramid

The vestibules are scrubbed with green soap on cotton applicators and frequently douched with warm sterile water, to free the nose of dried mucus, cut hair and other foreign bodies. The cleansing should be done gently, since the mucosa is easily traumatized. The vestibule is then swabbed with ether and thoroughly dried After the cleansing the nasal fossae are anesthetized A single strip of ½ inch gauze wrung dry

of a solution of equal parts of 10 per cent cocain and 1:1000 adrenalin is introduced into each nasal fossa and snugly packed against the septum As a rule, 5 to 6 cc of the solution will suffice The packing is removed in 40 minutes. Or, anesthetization of the nasal mucous membrane may be brought about by a direct blocking of the sensory nerves, each nostril being treated as follows (fig 292-(2)) Three cotton applicators are moistened with adrenalin and dipped in dry cocain crystals One of these is introduced into the nostril and pressed against the posterior end of the middle concha, desensitizing the sphenopalatine nerve and ganglion, which supply sensation to the floor and roof of the nose and to the posterior part of the lateral walls and septum A second applicator is applied to the mucous membrane at the root of the nose over the site of the nasal branch of the ophthalmic nerve, which supplies the anterior part of the lateral nasal wall and the anterior part of the septum The third is applied along the nasal floor to block the ethmoidal nerve The applicators are removed in a few seconds, and the manoeuver repeated 3 times at 5-minute intervals. Caution must be exercised in the use of cocain, since it is highly toxic Children and the aged tolerate it badly, and some individuals have an idiosyncrasy to the drug In no event should more than 1 grain of cocain be used, and the patient should be warned against swallowing the solution As a precaution against the latter contingency, the tampons should be well squeezed out before they are introduced into the nostrils In the presence of an idiosyncrasy, eucain may be substituted, but the action of this drug is slower, and the vasoconstriction it occasions is less complete

Just before the patient enters the operating room, the hair is covered with a rubber cap, and if cocain packs have been used, they are removed at this time The patient is placed on the table with his head and shoulders somewhat elevated to aid manipulation and to minimize nasal congestion and hemorrhage Two sterile towels are laid under the head The upper one is wrapped around the head turban-fashion and secured in place with towel clips A drop of sterile castor oil is introduced into each eye, and the entire face and vestibule are scrubbed with green soap and water for 5 or 6 minutes, being frequently rinsed with sterile water The face is then dried with sterile gauze and swabbed first with alcohol and then with ether To prevent the escape of blood into the nasopharynx, a sterile pack is introduced high up into each nostril, the vestibule being left clear (fig 292-(3)) Finally, the patient's eyes and mouth are covered with strips of gauze (fig 292-(4)), and anesthesia of the external nose is begun

Anesthesia. Practically all nasal operations of this type are performed under local anesthesia, as the face is thus left in full view In those cases where local anesthesia is for some reason contraindicated, general anesthesia by endotracheal induction is the best alternative (p 433) If a local agent is to be used, the field of operation is walled off with 30 to 40 cc of a 1 per cent solution of procain to which have been added 10 drops of a 1 1000 solution of adrenalin The anesthetization is best carried out intranasally In this way the pain of the initial prick of the needle is eliminated, as the mucous membrane has already been made insensitive by the cocain pack Anesthesia is begun by infiltration of the dorsum A long needle is inserted intranasally at a point between the upper and lower lateral cartilages and is advanced subcutaneously to the glabella, the solution being delivered slowly as the needle is withdrawn (fig 292-(5)) Next, the lateral walls are infiltrated by inserting the needle into the vestibule at the base of the ala and advancing it to the nasofrontal suture, the solution likewise being delivered as the needle is withdrawn (fig 292-(6)) Through the latter point of entry the needle is

again inserted, the solution this time being delivered beneath the periosteum Finally, with a shorter needle, the base of the nose is infiltrated by *radial injections around* its circumference (fig 293-(7), (8))

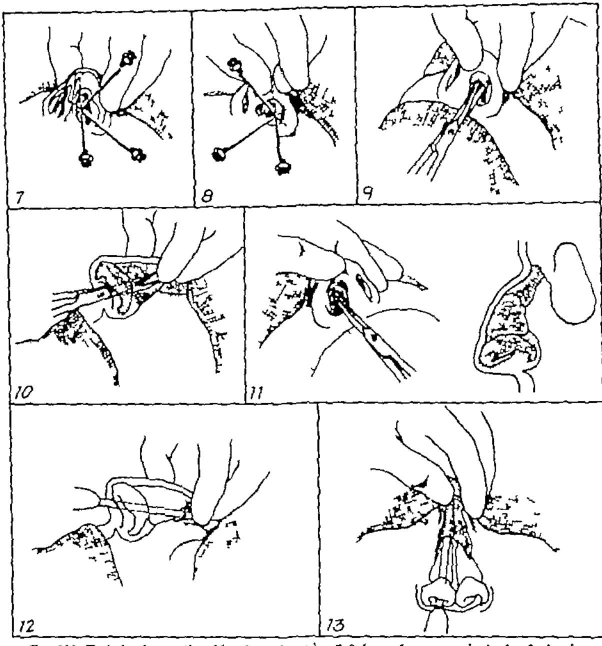


FIG. 293 Technic of corrective rhinoplasty (cont.) *7–8* base of nose anesthetized. *9* tip of nose retracted, and incision made between upper and lower lateral cartilages with double-edged scissors. *10* skin undermined laterally to nasolabial fold and medially to nasal dorsum. *11*, intranasal incision made on opposite side. *12–13* periosteum elevated through initial intranasal incision.

Operative Technic

Approach to Nasal Framework. The tip of the nose is retracted with the left thumb and index finger, a pair of double-edged scissors or a knife is introduced into the left vestibule between the upper and lower lateral cartilages, and the aponeurosis connecting the two cartilages is incised (fig 293 (9)) Through this incision a pair of scissors is carried beneath the skin over the upper lateral cartilage as high up as the nasal bone. The blades of the scissors are opened, undermining the skin laterally to the nasofacial fold

and medially to the nasal dorsum (fig 293-(10)). The same procedure is repeated on the opposite side through a similar incision (fig 293-(11)) After the detachment of the skin from its subjacent structures, the periosteum is elevated through the initial intranasal

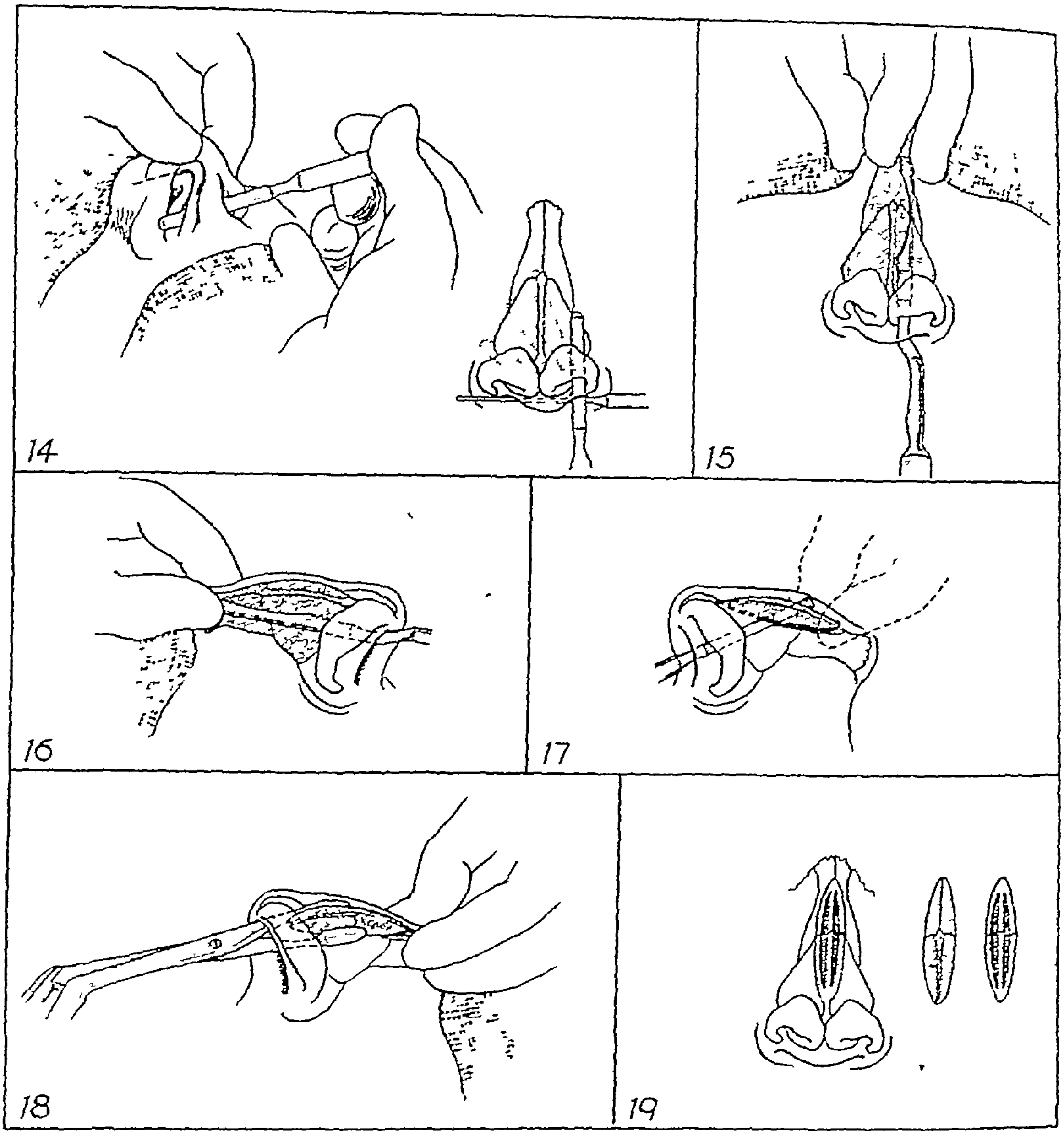


FIG 294 Technic of corrective rhinoplasty (cont) *14*, button-end scalpel introduced through initial left incision, passed over dorsum, carried down to emerge through opposite nasal incision, and turned at right angles to follow course of caudal extremity of septum, cutting through septum to nasal spine Insert shows course of knife *15*, with skin protected by thumb and forefinger, bony and cartilaginous elements and perpendicular plate of ethmoid cut through with saw *16*, bony and cartilaginous elements of opposite side cut in similar manner *17*, button-end knife introduced beneath severed bony section and drawn down to tip of nose, thus completely freeing all remaining attachments *18*, section of bone and cartilage removed with forceps *19*, appearance of nasal dorsum after removal of hump Inserts show outer and inner surfaces of bone and cartilage removed

incisions (fig. 293-(12), (13)) Following the separation of the soft parts a button-end scalpel is introduced through the left incision, passed directly over the dorsum, and carried down until it emerges through the opposite nasal incision, at which point it is

turned at right angles and made to follow the course of the caudal extremity of the septum, cutting through the membranous septum almost to the nasal spine (fig 294-(14))

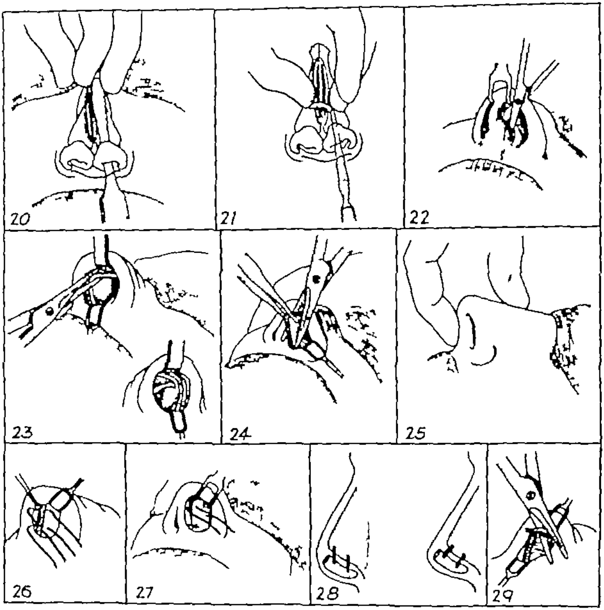


FIG 295 Technic of corrective rhinoplasty (cont.) *20* Irregularities of bony dorsum smoothed with rasp *21* cartilage trimmed with angulated knife. *22* membranous septum divided as far down as nasal spine. *23* upper lateral cartilages separated from septum by division of intervening angle with blunt scissors. Insert shows cartilage after division. *24* nose shortened by removal of triangular section with Mayo scissors while septum is steadied with forceps *25* *amount of shortening tested by* applying columella to septal cartilage. *26–27* columella reattached to septal cartilage by 2 heavy silk sutures *28* sutures placed obliquely so that when tied tip will tilt forward and upward, to compensate for subsequent contraction along line of union. *29* protruding *portions of upper lateral cartilages* trimmed.

Removal of Hump A nasal saw is introduced through the initial incision and placed flush with the hump at the exact level at which the profile is to be reduced. The thumb and forefinger of the left hand are placed on the side of the nose as a protection to the skin and a precaution against slipping of the saw With a few vigorous thrusts of the instrument the bony and cartilaginous nasal elements and the perpendicular plate

of the ethmoid are cut through (fig 294-(15)) The saw is removed and the procedure repeated on the opposite side (fig 294-(16)) A blunt-end knife is now introduced and engaged under the upper end of the severed bony section and is drawn downward to the tip of the nose, completely freeing the section of all remaining attachments (fig 294-(17)) The section of bone and cartilage thus liberated is extracted with a stout forceps (fig 294-(18),(19)) All irregularities of the bone which now remain are smoothed off with a rasp (fig 295-(20)) and the cartilage is trimmed with an angulated knife (fig 295-(21))

Following the removal of the hump, the membranous septum is cut through as far down as the nasal spine (fig 295-(22))

Shortening of Nose. Through the original intranasal incision the upper lateral cartilages are separated from the septum by a division of the intervening angle on either side with a pair of blunt scissors (fig 295-(23)) The soft tissues are then drawn aside by means of blunt retractors, and the caudal margin of the septum is made to present through the nostril The protruding septum is steadied with a toothed forceps, and with a pair of Mayo scissors a triangular section of a size sufficient to effect the required shortening is removed, the base of the triangle being directed upward and the apex toward the nasal spine (fig 295-(24))

When the nose has been reduced (fig 295-(25)), the columella is reattached to the septal cartilage by means of 2 heavy silk sutures passed through the entire thickness of both structures (fig 295-(26), (27)) To compensate for the subsequent contraction that inevitably takes place along the line of union, these stitches should be placed obliquely, so that when tied the tip will tilt slightly forward and upward (fig 295-(28)) After the sutures are tied, it will be found that the upper lateral cartilages, which are now too long for the shortened nose, protrude for a considerable distance into the vestibule These are excised flush with the incision, so that the margins of the wound will fall together (fig 295-(29))

Narrowing of Arch. Following excision of the hump, there remains on the dosum a flat triangular defect, the apex of which points toward the nasal arch, the lateral walls standing out vertically on the maxilla This defect can be eliminated and the arch given a more regular form by fracturing the frontal processes of the maxillae and displacing them toward the median line A pair of double-edged scissors or a knife is thrust into the mucosa of the left vestibule at the nasofacial junction and forced through the soft tissues until the pyriform opening is felt (fig 296-(31)) The periosteum is engaged with a periosteal elevator at the lower border of the pyriform opening and is elevated to the nasofrontal suture (fig 296-(33), (34)) The saw is introduced beneath the periosteum and engaged in the nasofacial groove, the base of the instrument being positioned at the outermost margin of the pyriform opening and the apex resting midway between the orbit and the glabella (fig 296-(35)) The position of the saw is maintained with two fingers of the opposite hand Then with an up and down movement about $\frac{2}{3}$ of the thickness of the bone is sawed through, care being taken to avoid piercing the mucosa The procedure is repeated on the opposite side (fig 297-(36)) The thumbs, protected by gauze, are now placed against the side of the bony framework, the fingers spreading over the opposite side of the face, and by the exertion of gentle pressure the fracture is completed, and the remaining attachments at the nasofrontal suture are separated, an audible click giving evidence of the desired result. This manoeuver is repeated on the other side A more precise method of mobilizing the bones is by the use of a Walsham for-

ceps (fig 297 (37)) The outer larger blade is applied to the outer lateral surface of the nose, and the inner smaller blade is introduced into the nasal fossa and held against the under surface of the incised bone. By a gentle rotary movement the fracture is completed, and the narrow articulation at the nasofrontal suture is separated (fig 297 (38), (39)) With the bones so liberated, there will be no difficulty in shifting the bony

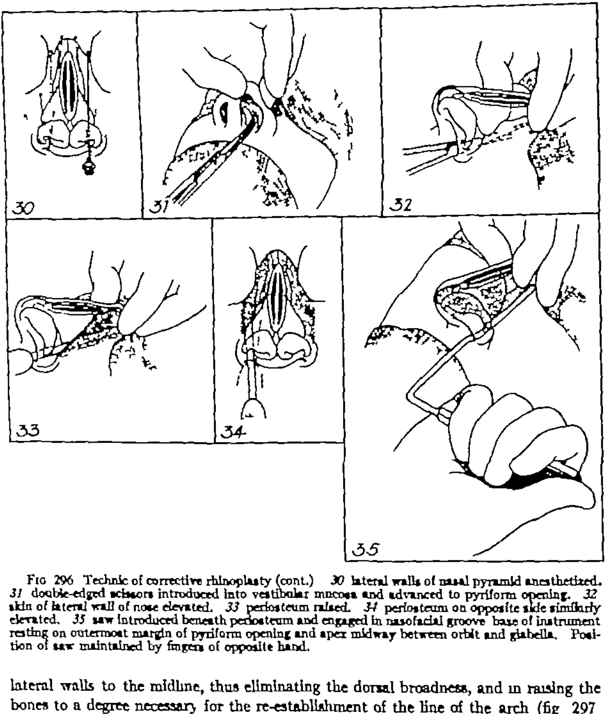


FIG 296 Technic of corrective rhinoplasty (cont.) *30* lateral walls of nasal pyramid anesthetized. *31* double-edged scissors introduced into vestibular mucosa and advanced to pyriform opening. *32* skin of lateral wall of nose elevated. *33* periosteum raised. *34* periosteum on opposite side similarly elevated. *35* saw introduced beneath periosteum and engaged in nasofacial groove base of instrument resting on outermost margin of pyriform opening and apex midway between orbit and glabella. Position of saw maintained by fingers of opposite hand.

lateral walls to the midline, thus eliminating the dorsal broadness, and in raising the bones to a degree necessary for the re-establishment of the line of the arch (fig 297 (40) (41)) The mobilization is not considered accomplished until the parts are capable of remaining in their proper positions without support.

Narrowing of Lobule. With the hump removed and the nose shortened and narrowed the lobule will appear too wide and must be reduced An incision is made in the

vestibule just below the inferior margin of the lower lateral cartilage (fig 297-(42), (43) A pair of double-edged scissors is introduced into the incision and brought out through the initial intercartilaginous incision, the instrument lying between the external skin and the cartilage (fig 298-(44)) The blades are now opened and the tissues separated

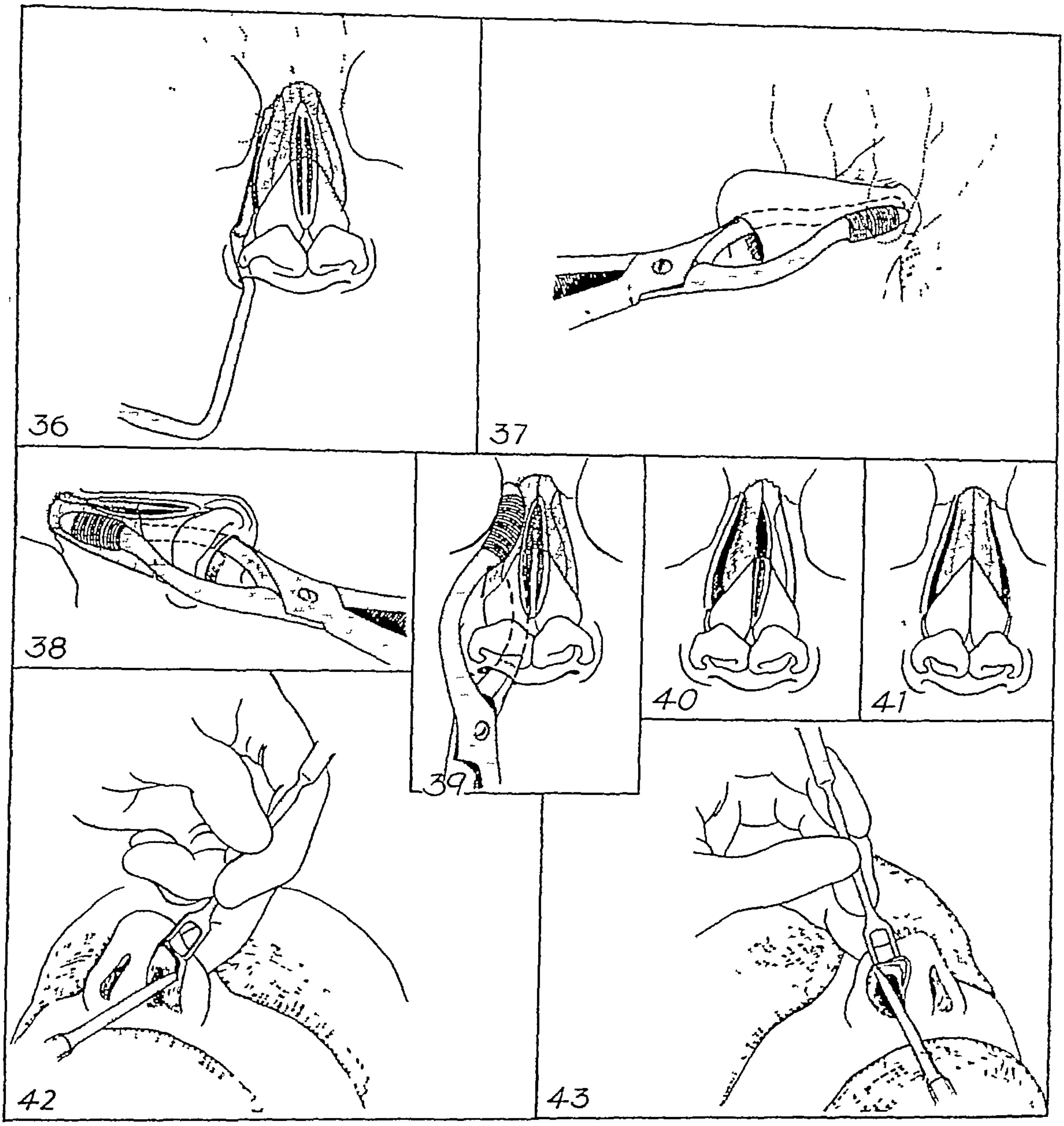


Fig 297 Technic of corrective rhinoplasty (cont.) *36*, bone on opposite side cut through *37*, nasal bones mobilized toward midline by use of Walsham's forceps *38–39*, fracture completed, and articulation at nasofrontal suture separated by gentle rotary movement of instrument *40*, lateral walls completely separated *41*, liberated bones shifted to midline, eliminating dorsal broadness and re-establishing line of arch *42*, lower lateral cartilages exposed by incisions made along their lower margins *43*, same procedure repeated on opposite side

laterally to the posterior termination of the alar crus and medially to the septum (fig 298-(45)). The cartilage is freed from the skin lining the vestibule in the same manner, except that now the scissors lie between the cartilage and the vestibular skin (fig 298-(46), (47)) The cartilage thus liberated is withdrawn from the vestibule by means of a

single-hook retractor and a strip of cartilage is resected from the angle (fig 298-(48)), the length and width of the strip being governed by the extent of the required reduction. *The separated parts of the lower lateral cartilage will fall into the midline* and the

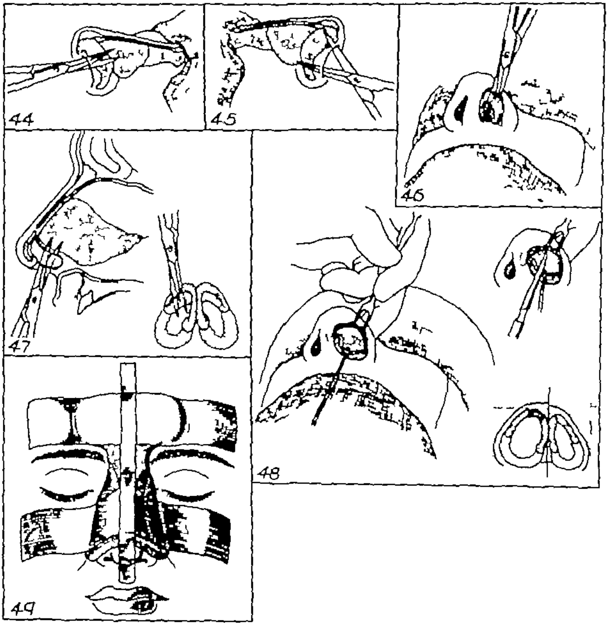


FIG. 298. Technic of corrective rhinoplasty (concl.) *44* double-edged scissors introduced into incision and brought *out through initial intercartilaginous incision* Instrument lying between skin and cartilage. *45* blades opened, and tissues separated laterally to posterior termination of alar crus and medially to septum. *46* vestibular skin separated from cartilage. *47* sectional view showing separation of vestibular skin. *48* liberated lower lateral cartilage drawn down with single-hook retractor *Upper insert shows strip being* removed from angle. Lower insert shows effect of resection *49* reconstructed nose immobilized by stent dressing held in place by adhesive tape.

reduction of the width of the nasal tip will equal the combined width of the sections of cartilage excised.

Dressing and Immobilization

At the completion of the operation all intranasal packs are removed, the nose is compressed from above downward to expel blood-clots, the face is cleansed with a moist

sponge, and the nares are lightly packed with xeroform gauze. Theoretically, if the nasal arch has been properly mobilized and set, splinting will not be necessary, as there are no muscles capable of causing redisplacement of the parts; but practically, for the first 48 hours it is desirable to apply a stent dressing to offset the possibility of disturbance by the patient in the early postoperative period A block of stent is softened in hot water, covered with a piece of felt to protect the skin, molded to the newly reconstructed nose, and allowed to harden, after which it is secured in place by means of adhesive strips extending from the forehead and across the cheeks (fig 298-(49))

Postoperative Management

The patient is put to bed on his back without pillows, and a sandbag is placed on either side of his head At the end of 48 hours the bandages are removed, the xeroform packing is withdrawn, and the nostrils are cleansed with hydrogen peroxid and lubricated with sterile albolene The patient is allowed to sit up in bed on the third day, discharged on the fourth day, and instructed to report for the removal of the two sutures on the fifth or sixth day. The average patient, following nasal reconstruction, passes through the postoperative period with remarkable smoothness Within a few hours after the operation there is usually a rise in temperature of $\frac{1}{2}$ to 1°, but this subsides rapidly The majority of patients feel no pain and require no medication If, however, pain is present, it can be relieved by the administration of a sedative, such as luminal 0 005 to 0 1 gram The development of any condition, however slight, which interferes with normal convalescence should be regarded as a complication, and it is of the greatest importance that it be investigated and treated at the very onset. The manifold phases of the postoperative treatment are discussed in detail in Chapter IX

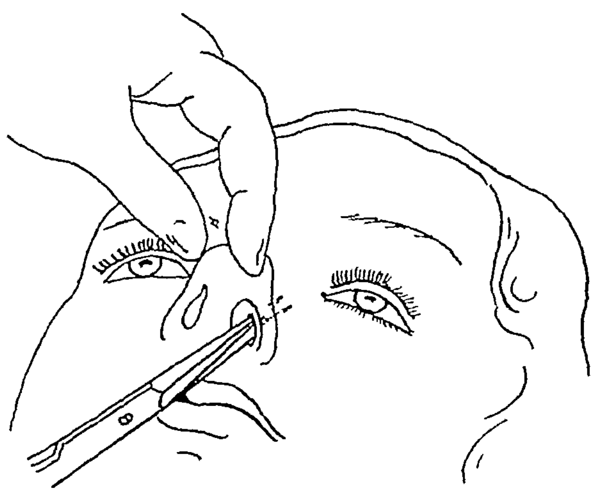


FIG 299 Approach to nasal framework Intranasal incision made between upper and lower lateral cartilages with double-edged scissors beveled to protect skin

Details of Operative Technic

Approach to Nasal Framework. The nasal framework may be approached through either an internal or an external incision

A Internal Approach

1 *Exposure of Osseous and Upper Cartilaginous Vault* a *Separation of Skin* With a pair of double-edged scissors or a double-edged knife an incision is made in the lateral wall of the left vestibule between the upper and lower lateral cartilages, care being taken to avoid injury to the cartilages during the incision of the connecting aponeurosis (fig 299) The line along which the incision is to be made can easily be gauged, as it corresponds to an anatomic shelf formed by the lower margin of the upper lateral cartilage when the tip of the nose is retracted The advantage of this incision is that it follows anatomic raphés and prevents severance of the angular artery and septal branches of the superior labial.

Through the incision thus made a pair of scissors or a knife—curved on the flat to permit of its accommodation to the convexity of the nasal arch, beveled as a protection to the skin, and sharpened on both sides—is carried beneath the skin over the upper lateral cartilage but not over the nasal bone The skin is undermined laterally to the

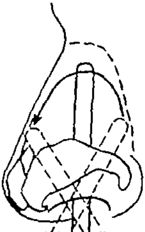
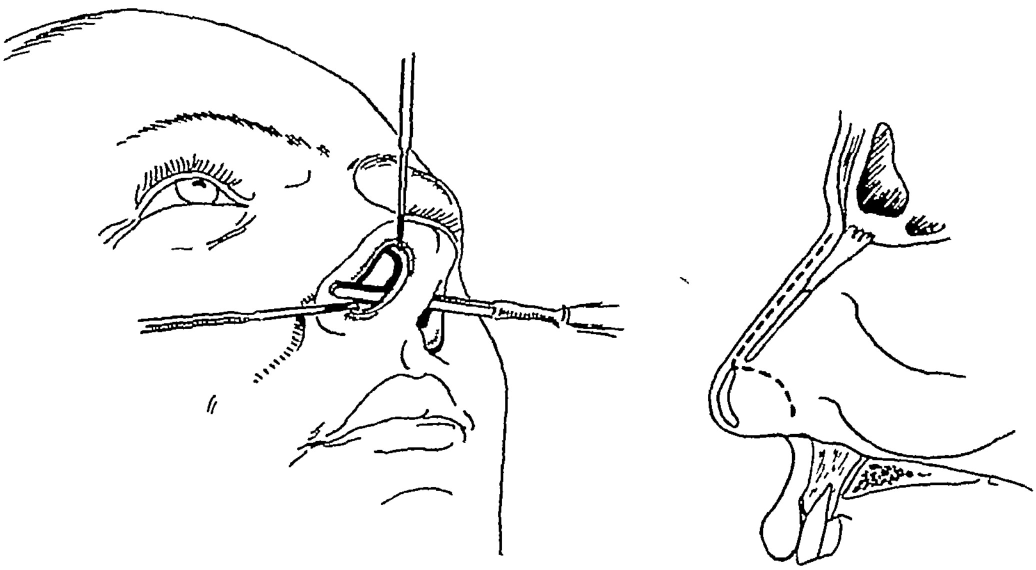


FIG 300 Separation of skin. Knife carried laterally to nasofacial fold and medially to dorsum. Solid red line shows course of knife Dotted red line shows separation of skin above lower lateral cartilages at later stage of operation.

nasofacial fold and medially to the nasal dorsum. During the undermining the fingers of the left hand on the outside of the nose follow the course of the scissors or knife, in order to protect the skin and inner canthal vessels from injury (fig 300) The procedure is repeated on the opposite side through a similar incision.

It is not advisable to carry the separation much beyond the deformity because the trauma of extensive separation invariably delays convalescence However it is essential that the detachment be complete, *so that the skin by its inherent elasticity will* be enabled to readjust itself to the reconstructed nose If connective tissue strands are allowed to remain attached, their subsequent contraction will result in dimpling, cyanosis, and tenderness of the overlying skin. Separation of the tissues by the use of a knife or double-edged scissors has the advantage over blunt dissection in that it minimizes trauma and leaves no irregular surfaces as lodging places for bacteria and accumulated blood-clots. Bleeding is usually not extensive and can be controlled by pressure with hot compresses placed over the nose. The use of adrenalin packs should be avoided, for while they check the flow of blood, they lead to postoperative congestion, hemorrhage and hematomata

b *Separation of Periosteum* After the skin has been detached from its subjacent structures, the periosteum is elevated to expose the bone Through the intranasal incision already made a small periosteal elevator is introduced and made to engage the periosteum at the caudal margin of the nasal bones The instrument is worked from side to side until the periosteum has been freed completely The same manoeuver is carried out on the other side A blunt-end scalpel is then inserted into the left intranasal incision, carried up under the freed periosteum to the nasion, swept downward over the dorsum to the end of the septal cartilage, and made to present through the incision on the opposite side, thus transfixing the nose (fig. 301) The knife, without being removed, is turned at right angles, drawn down, and made to cut through the membranous septum to a point about midway between the tip of the nose and the nasal spine, and is removed With a pair of Mayo scissors the division of the membranous septum is then completed down to the nasal spine While it would seem more con-



a b

FIG 301 Transfixion of nose *a*, button-end scalpel inserted into left intranasal incision, carried up under freed periosteum to nasion, swept downward over dorsum to end of septal cartilage, and made to present through incision on opposite side *b*, sectional view, showing course of knife

venient to finish this part of the operation with the transfixing knife, this is actually impracticable, since the knife is in such a position that if carried further downward it would be likely to cut the lower projecting part of the septal cartilage attached to the spine

2 *Exposure of Lower Cartilaginous Vault* Deformities of the lower lateral cartilages may be exposed for manipulation in two ways. (a) An intranasal incision is made in the lateral wall of the vestibule along the junction of the upper and lower lateral cartilages Another incision parallel to the first and of approximately equal length is made just below the inferior margin of the lateral crus A pair of double-edged scissors or a scalpel curved on the flat is introduced into the lower incision, forced between the lateral crus and the external skin, and made to appear through the upper intercartilaginous incision (fig 302-a). By working the knife back and forth or by opening the scissors the outer skin is separated from the cartilage, the dissection being carried laterally to the posterior termination of the alar crus and medially to the septum.

The instrument is removed and reinserted through the same incision between the cartilage and the skin of the vestibule, and the vestibular skin is separated in the same

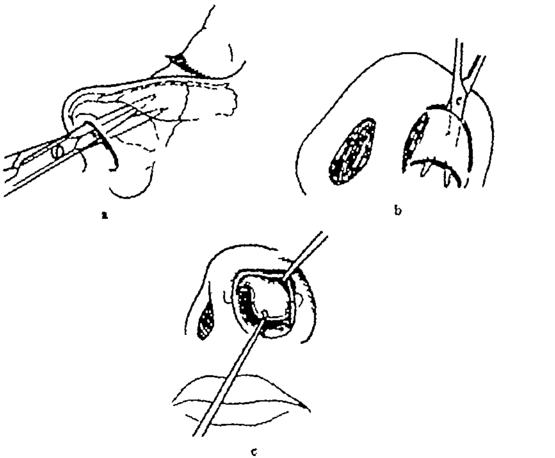


FIG 302 Exposure of lower lateral cartilages *a*, double-edged scissors introduced into incision in vestibule just below inferior margin of lower lateral cartilage, instrument lying between external skin and cartilage. Skin separated from cartilage by opening scissors. *b* vestibular skin freed from cartilage. *c* liberated cartilage withdrawn from vestibule by single hook retractor

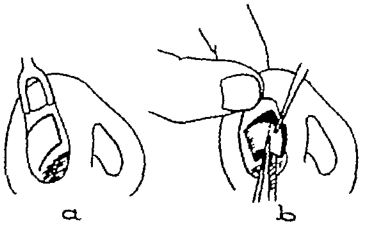


FIG 303 Exposure of lower lateral cartilage through flap incision. *a* flap of vestibular skin and cartilage outlined. *b* flap brought down and trimmed. For details, see text.

manner (fig 302 b) The cartilage thus freed on both surfaces is pulled out with a dural hook (fig 302-c) and dealt with

(b) Two parallel intranasal incisions are made one between the upper and lower

lateral cartilages, and the other along the lower border of the lateral crus The knife or pair of scissors is introduced into the lower incision and brought out through the upper, the instrument lying between the external skin and the cartilage By separating the tissues a double-pedicled flap is formed composed of cartilage and vestibular skin attached anteriorly to the septum and posteriorly to the ala The anterior pedicle is cut, and the flap still attached at its posterior extremity is everted with a hook, the structure being thus exposed for manipulation (fig 303)

The writer prefers the former method of exposure, because in the latter procedure the pedicle of the flap is so narrow that there is danger of subsequent necrosis; furthermore, the cicatrization accompanying the healing process has a tendency to deform the nostrils.

The greatest advantage of the intranasal method of approach is that it leaves no external scar, but many surgeons disregard this advantage in their fear of infection. Experience has demonstrated, however, that the intranasal incision involves no greater risk of infection than does the external approach The skin lining the vestibule can be sterilized as readily as that of the outer nose, and the nasal mucous membrane, if

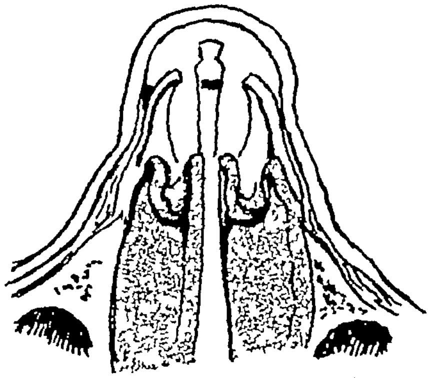


FIG 304 Exposure of nasal framework subcutaneously and submucously Sectional view, showing separation of skin and mucosa from bone Horizontal line indicates site of incision (Eitner)

healthy, is especially tolerant to infection and needs so surface sterilization. While unquestionably bacteria are present, they are not pathogenic to the host In an endeavor to eliminate the possible risk of infection arising from an intranasal incision and at the same time avoid an external scar, Eitner (58) exposes the framework subcutaneously and submucously, as follows (fig 304) An incision is made in the skin lining the vestibule along the anterior end of the septal cartilage Through this opening the soft parts covering the nasal pyramid are separated in the manner already described, the mucoperichondrium and mucoperiosteum are then dissected from the inner aspect of the nose. The overlying soft parts are drawn upward, and the lining membrane is drawn downward, thus exposing the nasal pyramid lying between the two layers While theoretically such an approach offers advantages, practically, the added trauma caused by the separation of the lining membrane probably offsets any benefits that might be derived from the procedure

B External Approach

The principal advantage claimed for the external incision is that the nasal cavity is left intact and thus unexposed to infection. However, when the anatomy of the nasal

pyramid is reviewed, it will readily be seen that such statements have no foundation, since any operation on the nasal bones, such as that for the removal of a hump, must necessarily open the nasal cavity Because the external method of approach leaves a surface scar, it has been generally discarded except in cases where a nasal cicatrix already exists. In such instances the excision of the scar provides a convenient access to the deformity (fig 305) Those who prefer the external method attempt to conceal

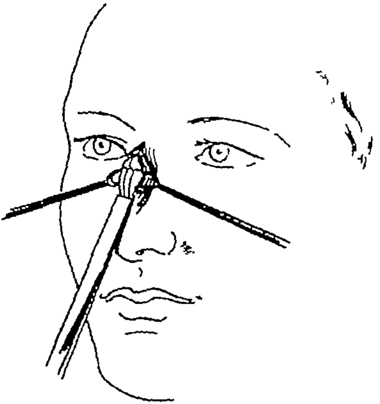


FIG 305. Nasal hump associated with scar over dorsum. Excision of scar provides convenient access for removal of hump.

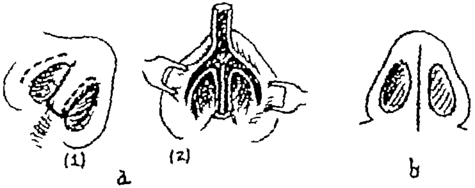


FIG. 306. External approach to nasal framework. *a* columella separated from its attachment to philtrum and septum *1* line of incision *2* columella separated and turned up. *b* incision made along vertical length of columella.

the scar by approaching the nasal deformity through one of the following incisions (1) just below the glabella (2) along the inner canthus, (3) through the eyebrow, (4) through the under surface of the tip of the nose, (5) through the vertical length of the columella or (6) through a separation of the columella from its attachment to the philtrum and septum, the columella being turned up in the manner of an elephant's trunk (fig 306)

Of the external incisions the one advocated by Réthi (253) is the best in that it permits of complete exposure of the nasal framework and yet leaves a minimum of external scarring The technic is as follows (fig 307): A horizontal incision is made across the anterior third of the columella and carried into the nostril for a distance of 2 or 3 mm At this point the knife is turned, and the incision is carried forward just below and parallel to the lower edge of the septum as far as the angle of the lower lateral cartilage The knife is again turned and the incision continued along the lateral

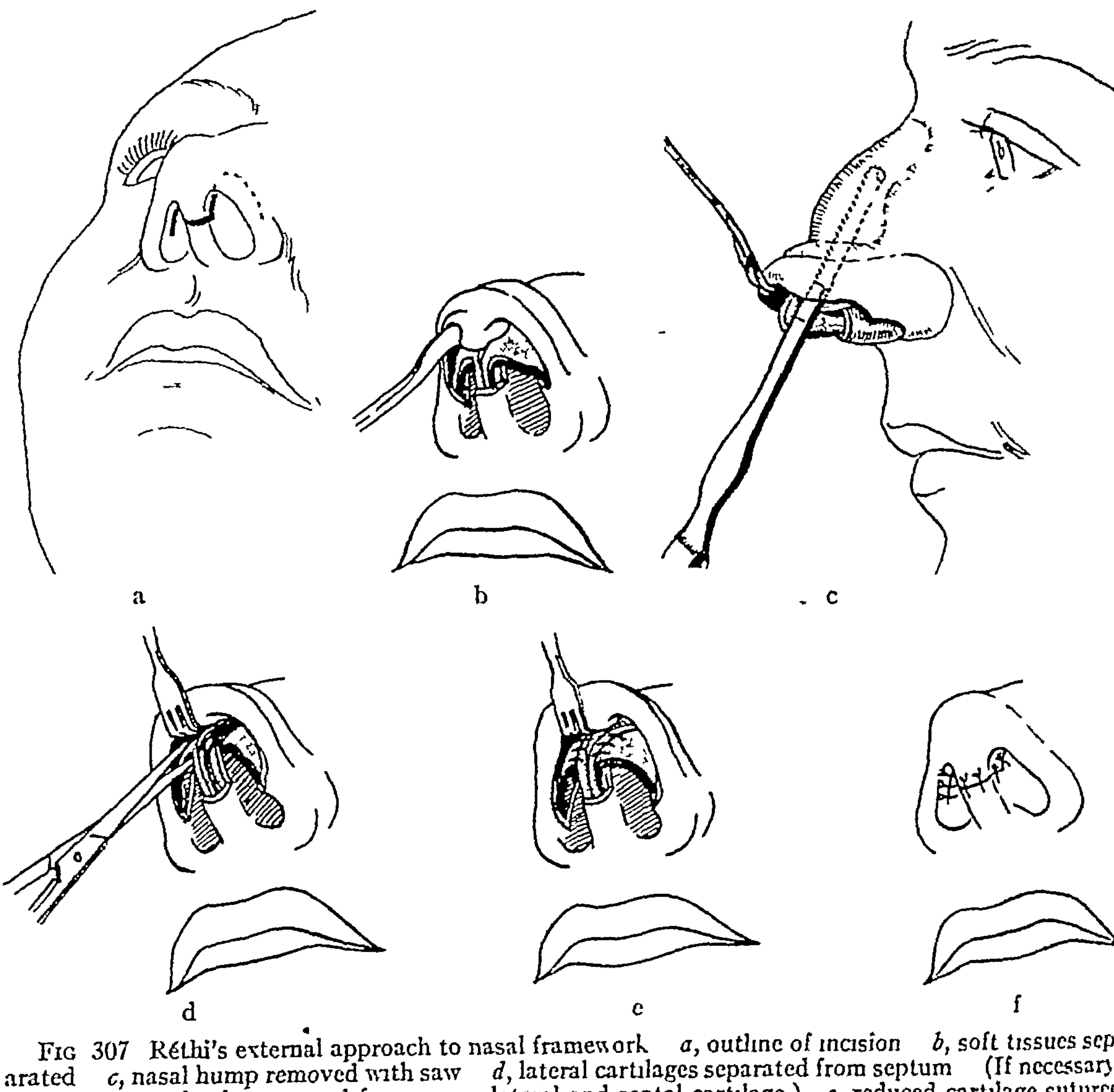


Fig 307 Réthi's external approach to nasal framework *a*, outline of incision *b*, soft tissues separated *c*, nasal hump removed with saw *d*, lateral cartilages separated from septum (If necessary, a section may also be removed from upper lateral and septal cartilage) *e*, reduced cartilage sutured back in place *f*, skin wound closed

wall of the ala between the upper and lower lateral cartilages, to end at the posterior termination of the lateral crus The opposite vestibule is similarly incised Through the incision thus made the soft parts are separated from the underlying framework as described above

Deformities of Bony Vault

The following descriptions of the technic employed in the readjustment of the nasal elements will proceed on the assumption that the intranasal type of incision has been

employed in the approach to the deformity, and that the nasal framework has been exposed by a separation of the skin and periosteum as described in the foregoing section

Hump Nose

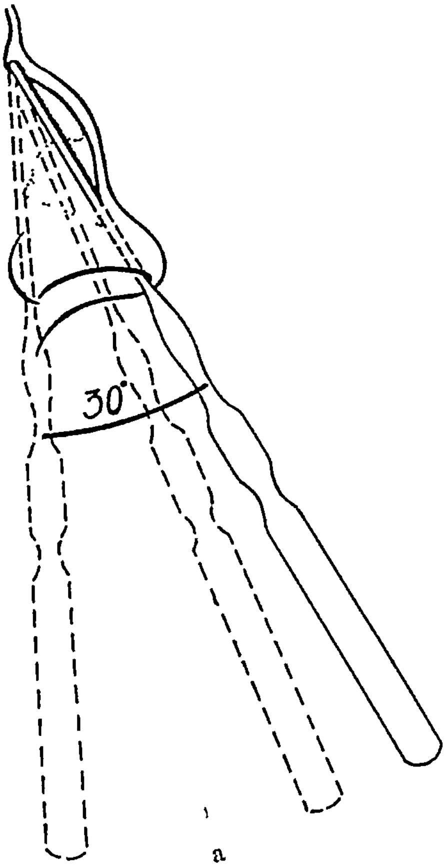
The hump nose deformity is rarely present at birth, it usually appears during the second decade of life as a result of hereditary predisposition. Occasionally a fall or some other violence applied to the nose is followed by the gradual formation of a boss. The traumatic type of hump nose can frequently be diagnosed by the presence of a scar over the convexity Pathologically, the defect may be an exostosis of the nasal bones or an osteophyte developed from the periosteum. The technical difficulty in the correction of this deformity is in inverse ratio to the size of the hump, which may vary from a barely perceptible elevation of the nasal bridge to a distinct and prominent boss involving the bridge or cartilaginous dorsum or both. It is nearly always associated with an abnormal breadth of the nasal bones and of the upper lateral cartilages.

1 *Excision of Hump* Small humps limited to the nasal bone may be planed off with a rasp Through the intranasal incision the skin and periosteum are elevated. A nasal rasp is applied to the dorsum of the nose, and with an up and down motion the hump is rounded off to conform with the normal nasal profile. The amount of reduction can easily be gauged by palpation through the overlying skin. The bone dust which remains is either removed with a dull curet or floated out with hydrogen peroxid introduced by means of a cotton applicator

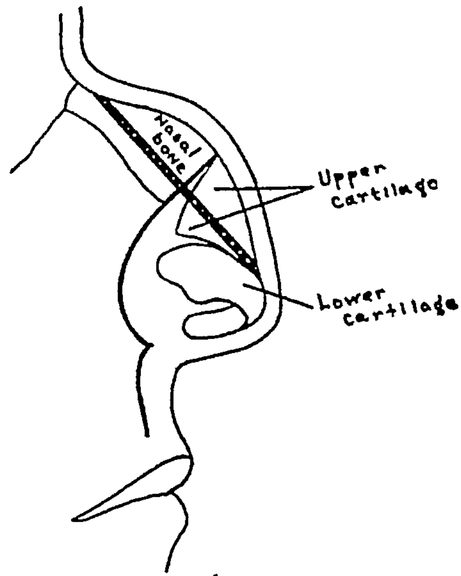
When the hump is limited to the cartilaginous dorsum, a blunt-end right-angled knife is introduced through the intranasal incision, and the cartilage is pared down subcutaneously to a normal profile.

For the removal of large bony humps a rasp is inadequate. The excision is best accomplished with a nasal saw In approaching this deformity it is not advisable to separate the periosteum from the bone. The hump should be removed with the periosteum intact, otherwise, the subsequent replacement of the traumatized periosteum will stimulate osteogenesis and may lead to a partial recurrence of the deformity The saw is introduced into the left intranasal incision and placed against the bone flush with the hump, at the exact level at which the profile is to be reduced, its position being gauged by external palpation and by the position of the handle of the instrument (fig 308) With a few vigorous up and down thrusts the nasal bone and the perpendicular plate of the ethmoid are cut through. During this manoeuver the thumb and forefinger of the left hand are placed against the skin overlying the saw in order to protect it, guide the course of the instrument, and keep it from slipping If the saw clogs, it must be removed and cleansed. After the nasal bone and the perpendicular plate of the ethmoid have been cut through, the nasal bone on the opposite side is severed in precisely the same manner Any remaining attachments of the hump with the septum, periosteum, or upper lateral cartilages are then separated by means of a blunt-end knife introduced beneath the upper extremity of the bony hump and drawn downward to the nasal tip (fig 309-a) The hump thus liberated is then lifted out with a stout forceps.

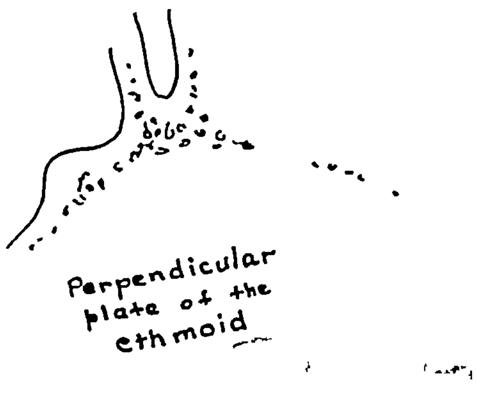
It is important that the hump be cut through equally on both sides, otherwise, there will remain an irregularity of the resected dorsum. In order to effect this, it is often convenient to excise the hump completely through the left intranasal incision. Some


30°

a


Nasal bone
Upper cartilage
Lower cartilage

b


Perpendicular plate of the ethmoid

advocate that the hump be removed with a chisel or an osteotome, and since less technical skill is required for the manipulation of these instruments, it is advisable that they be employed for the first few operations. But as soon as the operator becomes well acquainted with the technic, these instruments should be discarded in favor of the

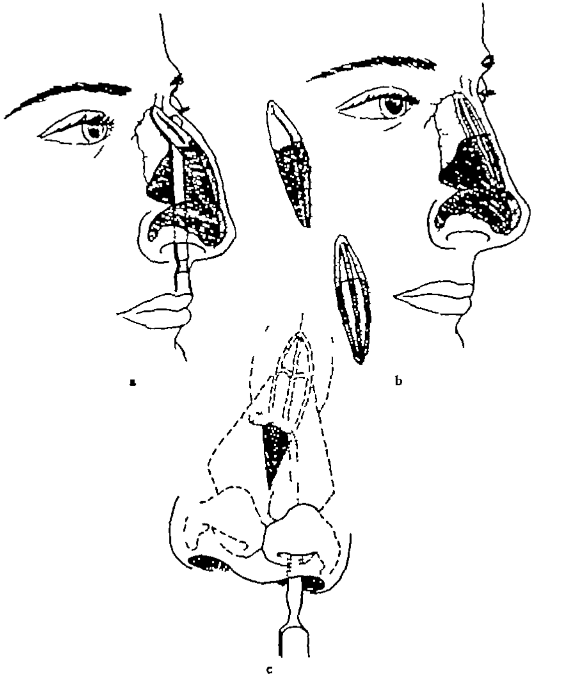


FIG 309 Removal of hump (cont.) *a*, remaining attachment of hump to surrounding soft tissue separated by blunt-end knife. *b*, defect left after removal of hump Insert shows anterior and posterior views of resected hump. *c* cartilaginous dorsum pared with button-end right-angled knife.

saw, because for mechanical reasons they cannot be prevented from cutting too deeply on the upward thrust, and thus yield inferior results. Kilner (144) has attempted to overcome this tendency on the part of the chisel by a specially designed instrument shown in Figure 310

After the excision of the hump the dorsum is palpated, and should it be found irregular or not sufficiently reduced, it is leveled off with a rasp If, on the other hand, too much of the dorsal arch has been removed, the excised hump is pared down to a size sufficient to restore the normal profile and is replaced as a transplant

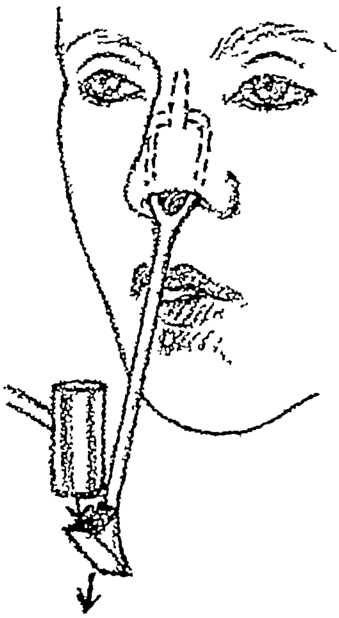


FIG 310. Instrument devised by Kilner to overcome tendency of chisel to cut too deeply on upward thrust

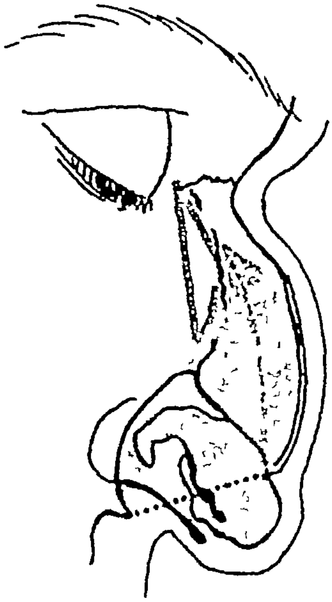


FIG 311 Lothrop's method for elimination of nasal hump Wedge-shaped sections excised from nasal bones and septum Dorsal hump forced back into space thus created, to produce normal profile

Some surgeons, following the technic of Goodale (84) (1899), Lothrop (184) (1914), Eitner (56) (1924), Dufourmentel (50, 51), and Moskovicz, correct the deformity without attacking the hump itself They excise a wedge-shaped section from the septum and also a wedge of bone from each side of the nose (fig 311) The space created by the removal of these substrata permits of the depression of the hump to the normal profile level

2 *Elimination of Subsequent Flatness of Bridge* As has been stated before, excision of the hump leaves on the dorsum a flat triangular defect (fig 309) In order that the arch may be given a more regular form, the frontal processes of the maxillae must be fractured and displaced toward the median line, as detailed on page 674 The space remaining between the maxillae and the re formed nasal arch will eventually be obliterated by osteogenetic organization. For reasons already given (p 685), resection of the hump subperiosteally is inadvisable, the bone being preferably removed together with its periosteal covering But in the performance of the lateral osteotomy for the purpose of narrowing the nasal arch, it will prove advantageous to carry out the procedure subperiosteally, since here the osteogenetic properties of the periosteum are necessary for the creation of a callus and for the anchoring of the bones in their new positions (fig 296)

FIG 312. Result following removal of hump due to old fracture, with bones united in overriding position.

Figure 312 shows the result of the removal of a nasal hump caused by faulty union of fragments following fracture

Abnormally Wide Bony Nose

In the hump nose deformity the removal of the hump automatically breaks the spring of the nasal arch and all that is required to narrow the nose is to mobilize the bones by means of lateral osteotomies of the frontal processes of the superior maxillae. But when the abnormally wide nose occurs as an isolated deformity, the narrowing can be accomplished only by a deliberate breaking of the spring of the arch This is accomplished by separating the nasal bones anteriorly from the septum on each side as well as posteriorly from the maxillae as follows Through the usual intranasal incision the periosteum is raised over the dorsum. A saw is then applied to the bone 3 mm distal to the median line, and the nasal bone is cut through The same manoeuver is repeated on the other side of the dorsum The frontal processes of the superior

maxillae are then severed on each side in the customary manner (p 674) (fig. 313) With the spring of the arch thus destroyed, the lateral walls can be shifted toward the median line, thereby decreasing the width of the arch

Occasionally, the abnormal breadth of the nose is caused by an undue thickness of the frontal processes of the superior maxillae which stand out as definite ridges In such cases the hypertrophied bone may be planed off with a rasp or chisel through the intranasal incision

Deflected Bony Nose

A deflected nose is a deformity characterized by a deviation of the nose from its central position The deviation may be unilateral, with a convex narrow side and a concave broad side, or bilateral, forming an S-shaped twist The defect is usually traumatic in origin, occurring as a result of force applied to the side of the nose Occasionally, the deformity may be simulated, either by a thickening of the frontal process

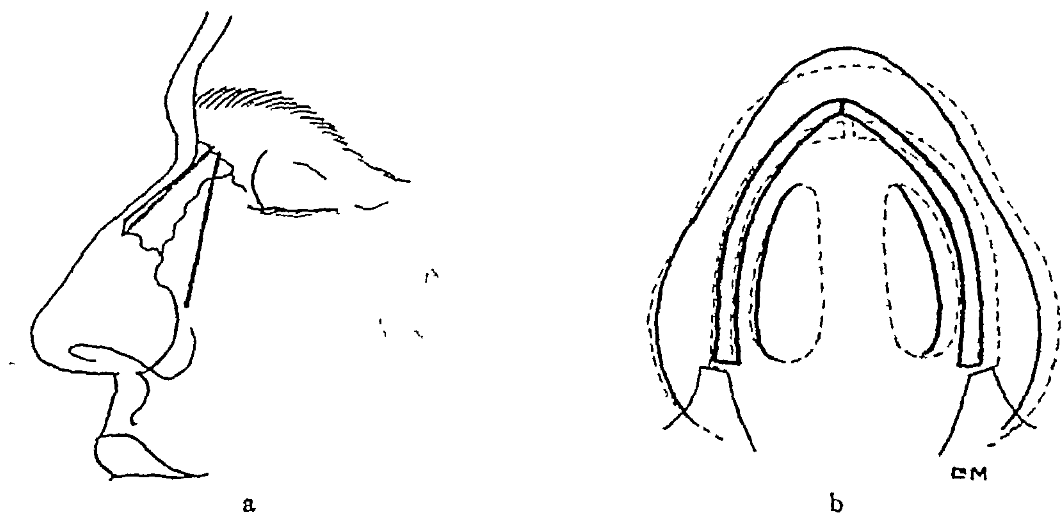


FIG 313 Reduction of abnormally wide nasal arch *a*, lines show position of saw-cuts through nasal bone and maxilla to break spring and mobilize nasal arch *b*, sectional view Solid lines show bone after repositioning

of the superior maxilla on one side, or by a thickening or hypertrophy of the overlying soft tissues

The operative procedure for the correction of this deformity will depend upon the character of the deflection, but in all cases the septum, which almost invariably is involved, demands primary consideration Properly replaced, it will provide adequate support for the repositioned nose and free the airway, but if not corrected, it will tend to cause a recurrence of the deformity

Attempts at correction of a deflected nose were made as far back as 1889 by Trendelenburg (311) Through intranasal incisions the frontal processes of the superior maxillae were cut through with a chisel The skin over the root of the nose was incised, and with a narrow chisel the nasal bones were separated from the frontal bone The septum was then cut through and the nose adjusted to the correct position. Because of the external scar and the tendency of the deformity to recur, this operation did not find many adherents

In 1901 Goodale (82) operated in much the same manner but eliminated the external

scar His technic was as follows The mucoperichondrium was separated along the whole length of the septum after which the latter was divided with scissors. The frontal processes of the maxillae were then sawed through, and the nasofrontal articulation was fractured by the application of external force to the convex side. With the parts thus mobilized, the osseous pyramid was repositioned and the nose brought into the median line.

While this operation did away with the external scar it did not prevent a recurrence of the deformity With a view to overcoming this tendency, Joseph modified Goodale's and Trendelenburg s operations by removing a triangle of bone from the broad concave side thus creating sufficient room for the shifting of the narrow convex side into the median line This procedure with various modifications, is still in use.

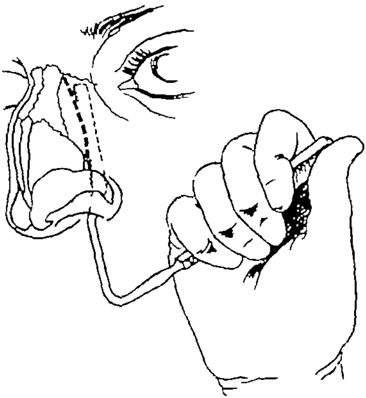


Fig 314 Correction of slight nasal deviation Frontal processes of superior maxillae cut through with saw Remaining attachment at frontonasal suture separated Nose manipulated into central position and retained in place with splint For details, see text.

Slight nasal deflections may be corrected in the following manner The saw is introduced through the usual intranasal incision, and the frontal processes of the superior maxillae are fractured as already described (fig 314), after which the nasal bones are forcibly separated from their attachments at the frontonasal suture The nose is then manipulated into a central position and retained in place by means of a splint. An objectionable feature of this procedure is the subsequent thickening on the concave side where the nasal arch overrides the frontal process of the superior maxilla.

In *more pronounced grades of deflection* it is necessary to remove a triangle of bone from the broad concave side in order to create room for the shifting of the narrow convex side into a more median position The technic is as follows (fig 315) An incision is made in the vestibule at the outermost margin of the pyriform opening on

the broad concave side of the defect A small periosteal elevator is inserted into this incision, and the periosteum is separated from the under surface of the bone The instrument is then introduced between the periosteum and the upper surface of the bone, and the membrane is elevated to the root of the nose For convenience the elevator is left in place, so that it may serve as a guide for the introduction of the saw, being removed only after the latter is in position The saw is placed on a line extending from the outer angle of the pyriform opening to a point midway between the inner canthus and the root of the nose While the fingers of the left hand elevate the skin and hold the instrument in place externally, the frontal process of the superior maxillary bone is cut through The saw is then removed and reinserted in a more anterior position It is so placed that its end will lie at the upper extremity of the incision already made and its base anterior to the lower extremity of the first saw-cut, a triangle with its apex pointing upward being thus outlined Obviously, the amount of

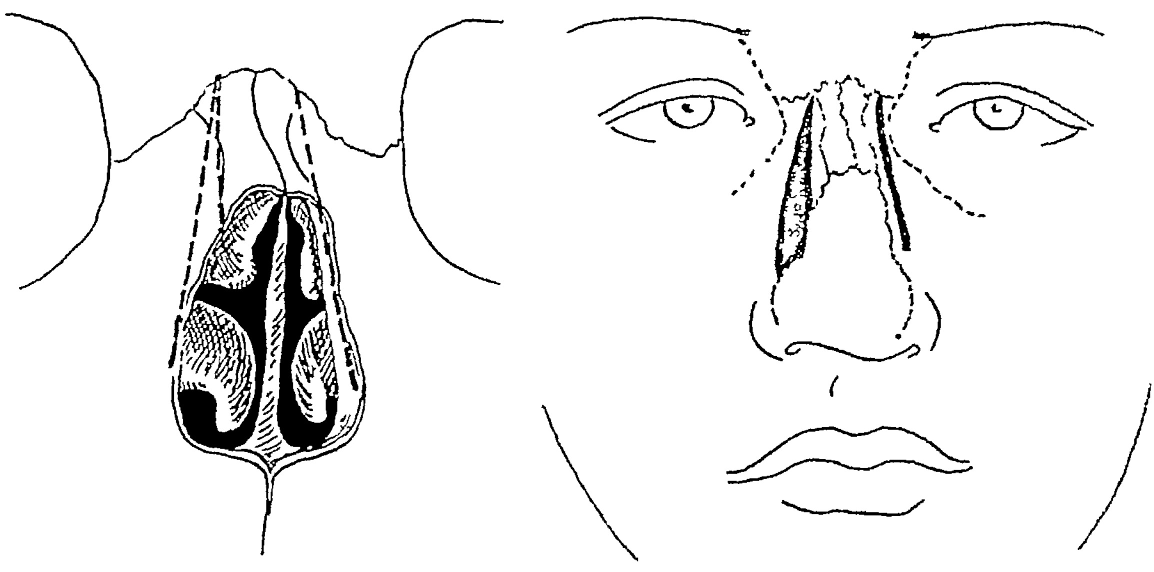


Fig 315 Correction of deflected bony pyramid *a*, shows saw-cuts on broad concave side, for removal of triangle, and on convex side for mobilization of osseous structures. *b*, triangle of bone removed, thus permitting shifting of narrow convex side to median line

bone to be excised will depend upon the degree to which the nose deviates from the midline With a few thrusts of the saw in this position the bone is cut through. The triangular section is removed with a forceps

On the convex or narrow side a similar intranasal incision is made, but here only the periosteum on the outer surface of the bone is raised The periosteal elevator is replaced with the saw as before, and a single saw-cut is made similar to the first one on the concave side (fig 315-a) Then with both thumbs, protected by a gauze pad, placed on the convex side of the nose and the fingers braced on the opposite zygoma, moderate force is exerted to fracture the nasofrontal suture and perpendicular plate of the ethmoid (fig 317-d). After the bones have been thus mobilized, the nose can be readily shifted into the [illegible] created by the removal of the triangular section of bone. If the cuts in the br[illegible] , the width of the nose at the frontonasal attachment may [illegible] cturing the bone into place without danger to the surr[illegible] circumstances, rather than use undue force, it

is better to make a small incision at the medial extremity of the eyebrow, undermine the skin to the nasofrontal suture, and introduce a small chisel. With a few blows of a mallet applied to the handle the frontonasal articulation can be fractured and the nasal arch mobilized. Occasionally, the bones on the concave side of the nose are thin enough to permit of the excision of the triangle with a pair of scissors, and in such cases the tedious labor of the sawing can be dispensed with. Repositioning should not be considered satisfactory until the nose can be made to stay in the median position without assistance Finally, a splint is applied to maintain the bones in their new relations and is left on until osteogenesis has taken place (p 631)

Lexer (169) operates in a similar manner but prefers to remove the triangle of bone through an external incision. Obviously, the objection to this method is the resultant scar

It has been suggested that the deformity be corrected by the removal of a section of bone from the wide side by means of an anterior excision. The method has little to recommend it except in those cases which present an abnormally high arch, since the operation necessarily involves a reduction of the nasal arch to the level of the convex side. Briefly, the procedure is as follows Through a vestibular incision on the convex side a saw is introduced, and a lateral osteotomy is performed in the usual manner The bone is then separated at the internasal suture, and the mobilized side is shifted to the midline. The broad concave wall will now be found to project beyond the line of approximation The protruding margin is removed with a saw or a pair of scissors. A lateral osteotomy is then performed on the flat concave side, and the nasal bones are shifted into a central position

The above procedures will be found inadequate for the correction of *exaggerated forms of deflected nose*, especially if the bone is thickened. For such cases an excellent procedure is that advocated by Lautenschlaeger (fig 316) The deformity is approached through an incision made in the oral vestibule along the upper gingivolabial sulcus. The soft tissues above the maxilla are separated with a dull elevator and retracted until the entire deformity is exposed. A triangle of bone is removed from the broad side with a saw, care being taken to avoid injury to the nasal mucous membrane On the narrow convex side the frontal process of the superior maxilla is separated, and the nose is fractured into a median position Recurrence of the deflection is prevented by the insertion of the spicule of bone removed from the broad side into the space created on the narrow side After the arch has been repositioned, the soft parts are replaced, and the wound in the oral mucous membrane is sutured. Finally, a compression bandage is applied. The extensive undermining incurred by the above procedure can be eliminated by introducing the graft intranasally, as depicted in Figure 317

Saddle Nose

The saddle-nose deformity is one characterized by an abnormally concave dorsum with an apparent upward tilting of the nasal tip With the exception of the hump nose, it is probably the most commonly encountered nasal disfigurement. The scapha results from a loss of dorsal support which may affect either the osseous or the cartilaginous vault or both and varies in depth from a shallow concavity to one so deep as to place the nose on a level with the zygomatic arches. The condition may be congenital or acquired If traumatic, it results from comminution and backward dislocation of

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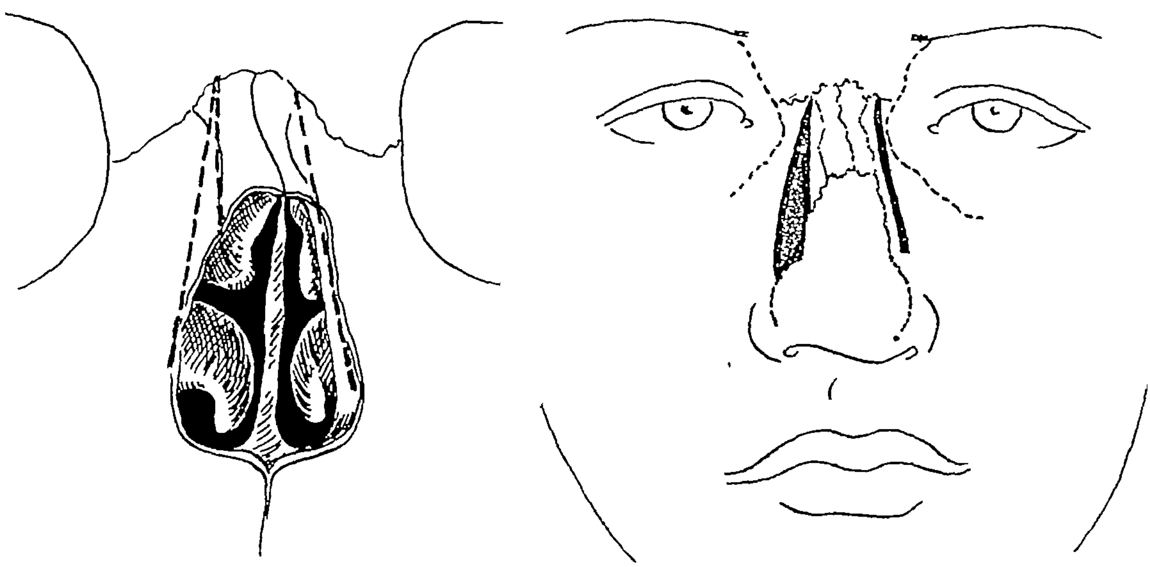

a b

FIG 315 Correction of deflected bony pyramid *a*, shows saw-cuts on broad concave side, for removal of triangle, and on convex side for mobilization of osseous structures *b*, triangle of bone removed, thus permitting shifting of narrow convex side to median line

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Saddle Nose

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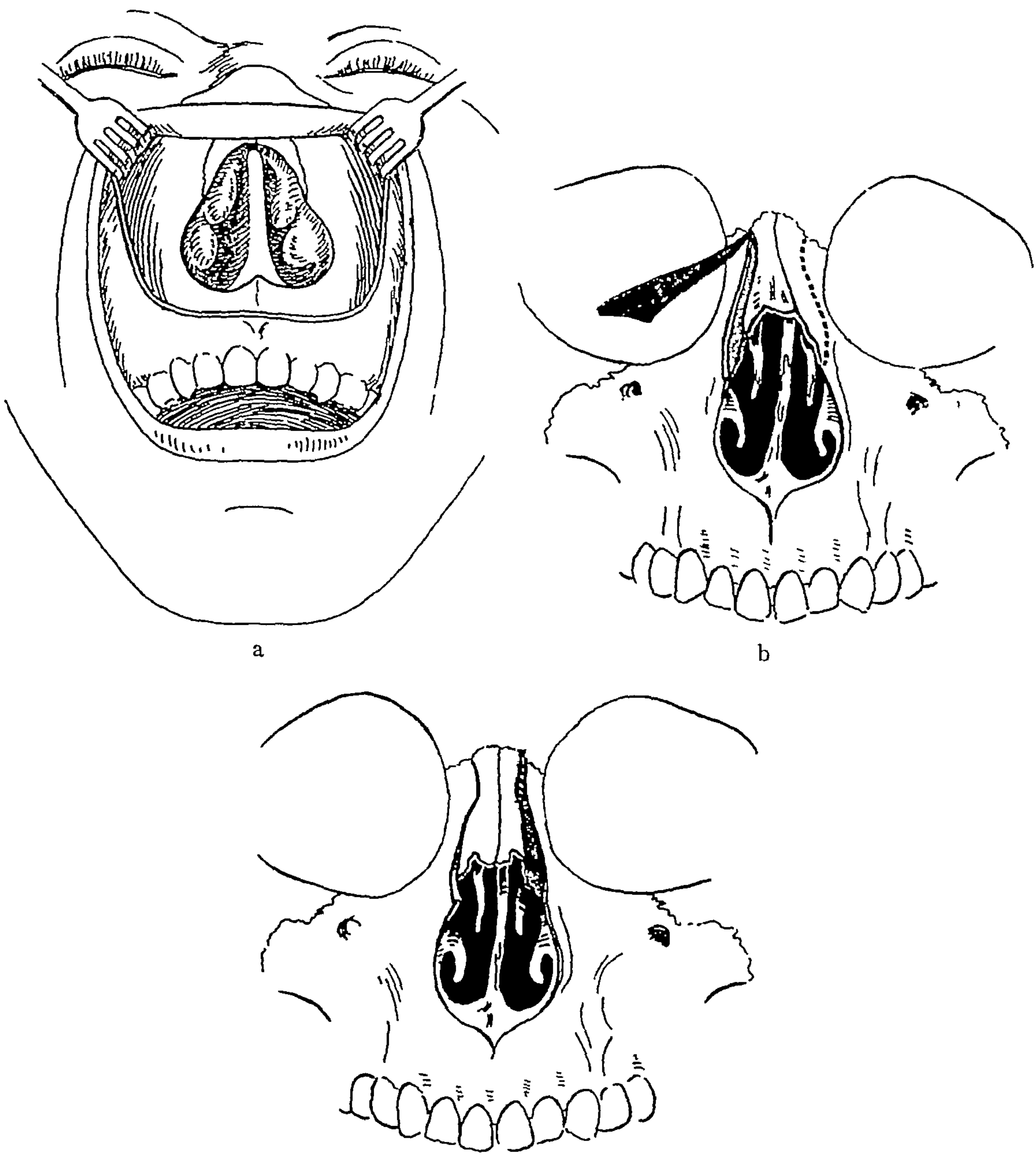
the nasal structures, complicated with more or less absorption of the elements Occasionally it is due to a faulty septal resection in which an insufficient buttress was left to support the dorsum and tip Not infrequently it occurs as a sequela to infectious processes, such as septal abscess, syphilis, or tuberculosis



a b c

FIG 316 Correction of deflected nose by use of inlay bone graft introduced through *extranasal* incision *a*, soft tissues elevated through gingivolabial incision *b*, triangular section removed from frontal process of superior maxilla on broad concave side Dotted line indicates saw-cut on convex side for mobilization of nasal pyramid *c*, bones mobilized and shifted into median position Triangle of bone previously removed inlaid between fragments on convex side, to prevent recurrence of deformity (Lautenschlaeger)

Classification of Saddle-Nose Deformities (1) *Saddle-nose involving only the supporting structures of the nose*, the overlying skin and mucous lining being intact (a) "*False*" *Saddle-Nose* A "false" or apparent saddle-nose is one in which the concavity

is simulated by the presence of an upturned nasal tip, the impression of a scapha being created by this disturbance of proportion In such cases the "disfigurement" disap-

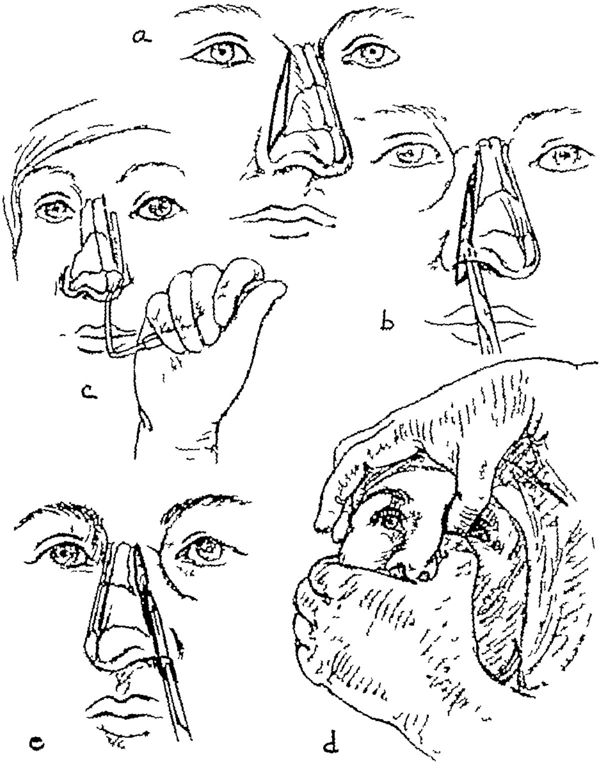


FIG 317 Correction of deflected nose by use of inlay bone graft introduced through *intranasal* incision *a* nose deflected toward left side. Triangle of bone to be removed outlined on broad concave right side to equalize nasal walls and create room for shifting of nose to median line *b* triangle of bone removed with forceps through intranasal incision. *c* osteotomy made through frontal process on left side to mobilize nasal pyramid *d* with thumbs protected by gauze pad placed on left convex side force exerted to separate remaining frontonasal attachment and shift nose to median line into created space *e* bone graft previously removed from right side introduced between fragments on left side to prevent recurrence of deformity

pears as soon as the nasal tip has been reduced The technic for the correction is given on page 722. (b) *True Saddle-Nose.* A true saddle-nose is one in which there has been an actual loss of the dorsal supporting structures This type of deformity can be corrected only by the replacement of the lost support with some sort of transplant. (2) *Saddle-nose involving not only the supporting structures, but cover and lining as well* The technic for the correction of these deformities is discussed in the section devoted to nasal deformities with loss of tissue

Choice of Corrective Procedure The method of correction to be adopted in the particular instance will depend upon the depth and site of the scapha, the movability of the overlying skin, and the presence or absence of cicatricial tissue

In *minor depressions* the ideal procedure is to reconstruct the nasal pyramid by a readjustment of the nasal elements already present. If the depression is located on

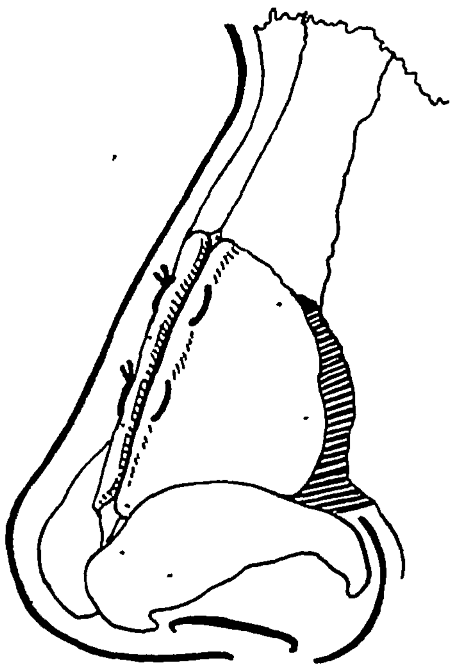


FIG 318 Correction of minor depression of upper cartilaginous vault Upper lateral cartilages separated from maxillae and septal cartilage, raised to required height, and fixed by suture passing through full thickness of nose (The more posterior the bite of the suture, the greater will be the elevation)

the bony dorsum, osteotomies are performed through the nasal bones where they join the osseous septum, and through the frontal processes of the superior maxillae (p 674) The remaining nasofrontal articulation is fractured by lateral digital pressure. The nasal bones thus freed are then elevated to the proper level and immobilized until organization has taken place If the depression is in the upper cartilaginous vault, correction can frequently be brought about by separating the upper lateral cartilages from the maxillae and the septal cartilage, raising them to the required height by digital manipulation, and fixing them by means of 1 or 2 sutures passed through the full thickness of the nose The more posterior the bite of the suture, the greater will be the resultant dorsal elevation (fig 318) A shallow scapha situated just above the nasal tip can often be eliminated by partially sectioning the lower lateral cartilages and swinging them upward hinge-fashion into the defect Figure 319 is self-explanatory

In the case of a shallow scapha along the entire lower half of the dorsum, Kazanjian (136) and Straith (301) turn up flaps taken from the upper and lower lateral cartilages on each side and unite them in the midline with a suture passing through the full thickness of the nose (fig 320)

If the concavity is situated just above the tip and is conveniently associated with an abnormally long nose, a shortening of the nose (p 707) will, as a rule, serve to obliterate the defect automatically When the saddle is accompanied by a hump, both deformities can often be corrected at one time by excising the hump and sliding it down to fill the concavity (fig 321) Likewise, if the scapha is associated with a deflection of the nasal pyramid, the triangle of bone removed from the broad side to permit of the shifting of the bone into the midline may be similarly employed for the obliteration of the defect. If the malformation cannot be corrected by a readjustment of the structural elements, it is frequently possible to conceal slight defects by filling them in with fragments obtained from the upper or lower lateral cartilages (fig 322) In such cases, obviously,

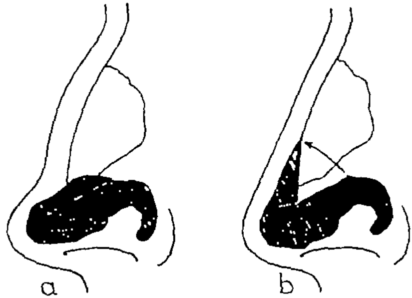


FIG 319 Correction of shallow scapha above nasal tip by use of flap from lower lateral cartilage swung hinge-fashion into defect. a, line of incision. b flap swung forward to obliterate defect.

care must be taken not to remove so much material that a secondary deformity will be created. These fragments are ideal for grafting purposes, as they do not disintegrate or change their consistency, and, when placed into the bed, they are received by the tissues without protest. If the thickness of one such fragment is insufficient to fill out the depression, several pieces superimposed upon one another and held together by means of a catgut suture may serve the purpose

In the case of *scaphas of marked degree*, wherein the structures in the immediate vicinity are not available in sufficient quantity, supporting material must be sought elsewhere

Choice of Transplant The qualifications of an ideal nasal transplant are that the material be readily available in sufficient quantity and of a consistency that will permit of easy modeling It must resist infection and absorption, be well tolerated by the tissues, and not subject to change in shape after implantation. To this end substances of all kinds have been experimented with, but autoplastic cartilage, introduced by

Nélaton (218) in 1900, is the material that most nearly meets the above requirements For this reason only passing reference will be made to the numerous other substances suggested

Of the *alloplastic substances* available for the building up of the nasal bridge white vaselin was chosen by Gersuny (69, 70) in 1900, in 1901 Eckstein (55) introduced paraffin, and others later used these two materials in combination While the primary re-

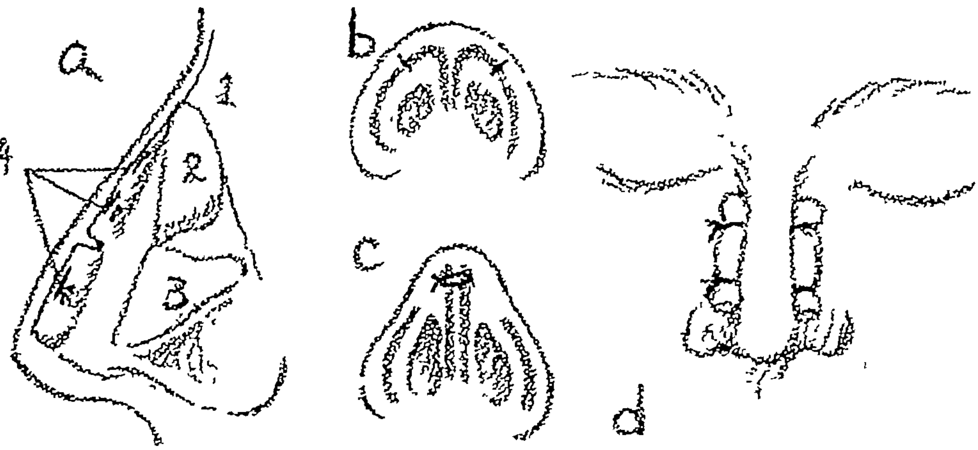


FIG 320 Correction of minor depression of cartilaginous dorsum by turned-up flaps taken from upper and lower lateral cartilages *a1*, nasal bones *2*, upper lateral cartilages *3*, lower lateral cartilages *4*, cartilage flaps, pedicled posteriorly, everted, and approximated *b*, sectional view, showing sites of incision *c*, sectional view, showing eversion and approximation of flaps *d*, everted flaps immobilized by mattress-sutures passing through cartilage and tied over gauze rolls (Kazanjian and Straith)

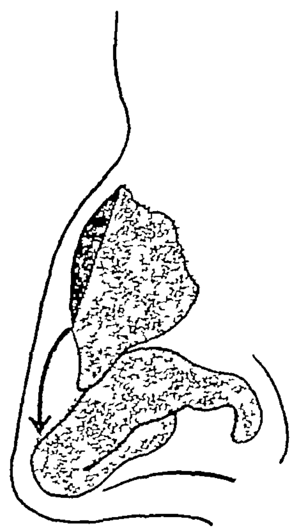


FIG *321* Simultaneous correction of saddle-nose and hump Hump excised and slid down to fill out depression

sults of such injections were satisfactory, the subsequent inflammation, ulceration, abscess formation at the point of injection, and the later diffusion of the paraffin into the surrounding tissues, together with the danger of embolism and the secondary changes in the tissues have condemned the use of both vaselin and paraffin in surgery Foderl (1903) employed celluloid, and others have reported satisfactory results with gold and silver implants Joseph (130, 133) (1918) was the first to advocate the use of elephant ivory and claimed for this material that it was non-absorbable and easily

sterilized For a time this substance enjoyed wide popularity While alloplastic materials may give immediate satisfaction, can easily be sterilized, and obviate the necessity of mutilating other parts of the body, their use is fraught with danger Like all foreign bodies, they are incapable of becoming incorporated as an integral part of the tissues and sooner or later, as a result of slight trauma are extruded by the processes of inflammation and ulceration

Soft tissue implants have also been experimented with and recommended on the grounds that they are more pliable and can be introduced piecemeal through minute incisions. A speculum is inserted into an intranasal incision and through the instrument fragments of soft tissue are delivered into a previously prepared pocket Of the soft tissue transplants periosteum was first used by Reverdin (254) (1879) muscle by Vighard, fascia by Koch (147) (1914), and bundles of catgut by Rueda (1913) Bovine cartilage is at present employed by Stout (297) (1933) The greatest disadvantage of these materials is their tendency to undergo absorption In order to overcome this

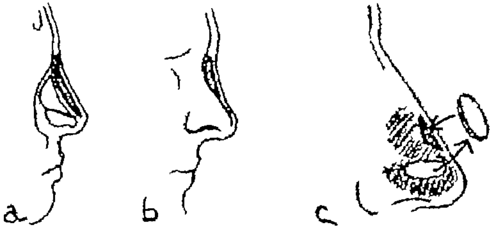


Fig 322. Correction of minor depression of nasal dorsum by use of fragments taken from septum and upper and lower lateral cartilages, to build out *a*, dorsal depression *b* osseous scapha *c* depression above tip

objection Magitot advocates fixing them in formalin before their introduction into the tissues.

Pierce (246) favors isografts of costal cartilage (p 183) These grafts are prepared as follows All soft tissue including the perichondrium is removed, the grafts are placed in a solution consisting of 1 part aqueous merthiolate and 4 parts normal salt solution and stored in a refrigerator After 3 days and again at the end of a week they are transferred to fresh solutions, after which they are cultured for sterility Pierce and O Connor have kept the cartilage immersed in solutions for as long as a year before use. They find these transplants superior to autografts in that they have less tendency to curl heal more firmly offer a greater resistance to infection obviate the necessity of painful operations on the chest, and reduce the time of hospitalization They have used this material in 162 cases with no untoward consequences. The question arises, however as to the ultimate fate of such transplants Peer recently found that "dead cartilage grafts buried from 9½ months to 2 years showed progressive invasion by fibrous tissue and partial absorption. In contrast to these findings autogenous rib cartilage grafts showed no invasion or absorption over the same period of time"

As has been said before *autoplastic grafts* give the best results, and *cartilage* is the

material which most nearly meets the requirements of an ideal transplant Because it is lymph-nourished and its metabolic processes are slow, it "takes" readily and is not liable to disintegrate or become absorbed, even in the absence of perichondrium It is easily obtained in any amount, can be trimmed to a suitable size and shape without difficulty, and has no tendency to be extruded Its only disadvantage is its failure to form an organic union with the nasal bones to which it becomes united only by means of fibrous tissue, and its proneness to curl when not properly modeled The technic for the removal of rib cartilage is described in detail in the section dealing with cartilage grafts

Osteochondral grafts obtained from the crest of the ilium or rib are especially desirable for the reconstruction of saddle-noses in children, since these transplants, unlike cartilage, form an osseous union with the remaining nasal bones and grow with them. Obviously, the osseous portion of the graft should be applied to the freshened bony portion of the existing nasal bridge, and the cartilaginous portion to the cartilaginous dorsum. These transplants are obtained from the ribs in the same manner as cartilage grafts, except that a portion of bone is resected together with the cartilage

Some surgeons favor *osteoperiosteal transplants*, on the grounds that they form an osseous union with the nasal bones and have no tendency to curl But this material is difficult to model and is prone to undergo absorption It is a well-recognized fact that bone grafts retain their viability only when placed in contact with bone throughout their entire extent Unfortunately, when this material is used in the nose, contact can be made only at the bridge, and for this reason the distal end tends to atrophy. In the cutting of these grafts the periosteum should be allowed to remain attached, not only because of its possible osteogenetic properties, but also for nutritional purposes, since anastomosis with the surrounding vessels takes place more readily through periosteum than through osseous tissue Osteoperiosteal grafts may be obtained from the rib, the tibia, or the crest of the ilium The method of securing the various grafts is described in detail in Chapter II

Preoperative Considerations Several months prior to the introduction of a transplant, various preliminary measures must be carried out to insure its success Obstructions to the airway and all traces of infection should be eliminated Scars over the nose extensive enough to suggest interference with the "taking" of the graft must be removed If the nasal pyramid is deflected or too broad, or if the septum is distorted, these structures must be first corrected

To insure precision in the shaping of the transplant, a cast of the deformity is made in quick-setting dental plaster (p 1387) On this cast the scapha is built up in wax or clay to slightly less than the normal contour, so as to compensate for the thickness of the tissues which are to overlie the transplant The wax or clay model is removed and cast in metal, in order that it may be sterilized with the instruments at the time of operation (fig 323) Where tip support has been destroyed and it becomes necessary to insert an angled graft, the distance from the glabella to the proposed tip and from this point to the nasal spine is calculated on the cast, and the graft is cut according to these measurements. Such preliminary measures will obviate the necessity of repeated trial insertions of the transplant and thus lessen the danger of infection

Operative Technic 1 *Preparation of Bed for Reception of Transplant* The first step of the operation is the preparation of the bed which is to receive the transplant The nose and surrounding parts are cleansed and draped and the parts anesthetized in

the customary manner As in the removal of a hump, the approach may be either intranasal or external, and for reasons already given (p 682) the former is preferable. For the insertion of an angulated graft the incision is made in the mucous membrane of the left vestibule between the lower edge of the septum and the medial crus of the lower lateral cartilage, care being taken to avoid penetration of the opposite wall. For the introduction of a dorsal graft it is made in the outer wall of the vestibule between the upper and lower lateral cartilages, (p 679) If an external incision is to be employed, the bed may be prepared through the opening left after the removal of a conveniently situated scar, through a central columellar incision, or by a reflection of the columella upward after its separation from the philtrum and membranous septum (figs. 327–328) The latter incision is especially convenient for an angled graft, the long limb being passed up along the dorsum and the short limb fitted against the lower edge of the septum and the nasal spine. When the columella is resutured to the philtrum and to the membranous septum on both sides, the entire transplant becomes enclosed.

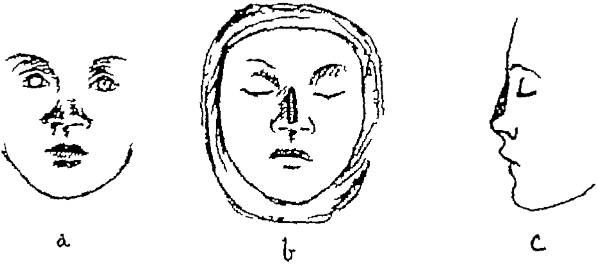


FIG. 323 Construction of cast of deformity *a*, saddle-nose deformity *b* scapha built up in wax on cast. *c* profile view Wax model cast in sterilizable metal and used as pattern for graft at time of operation, to obviate necessity of repeated trial insertions, with its attendant danger of infection.

Through one of the above incisions a small sharp tenotomy knife is introduced, and the soft tissues are separated from the dorsum to form a pocket of such a size as exactly to receive the graft If the pocket is too small, the tension produced after the introduction of the graft will interfere with the nutrition of the overlying skin, conversely, if it is too large, the transplant will have a tendency to slip out of position. The knife should be kept as close to the bone as possible, so that a thick layer of skin and subcutaneous tissue will be provided for the transplant. At the lower end of the bed the plane of dissection should be made close to the lower lateral cartilages, otherwise, the subsequent contraction of the soft tissues will cause traction on the graft and result in a distortion of the nasal tip If the tip of the nose as well as the dorsum requires support and an angled transplant is to be inserted, a pocket must also be made along the columella for the reception of the septal strut. At the upper end of the bed, in the region of the frontonasal angle, the periosteum is undermined for the reception and immobilization of the tapered end of the proposed transplant. The soft tissues having been elevated, a fine chisel is introduced and a gutter made along the surface of the dorsum.

In depressions involving but $\frac{1}{3}$ to $\frac{1}{2}$ of the dorsal length a better nasal contour and more satisfactory immobilization of the graft will result from shaving the entire dorsum down to an even plane and filling the scapha with a single long graft extending from the glabella to the tip of the nose, than from filling the cavity with a small graft

After the bed has been prepared, bleeding is controlled by gentle pressure over the dorsum with a pad of gauze wrung out of hot normal salt solution The surgeon and

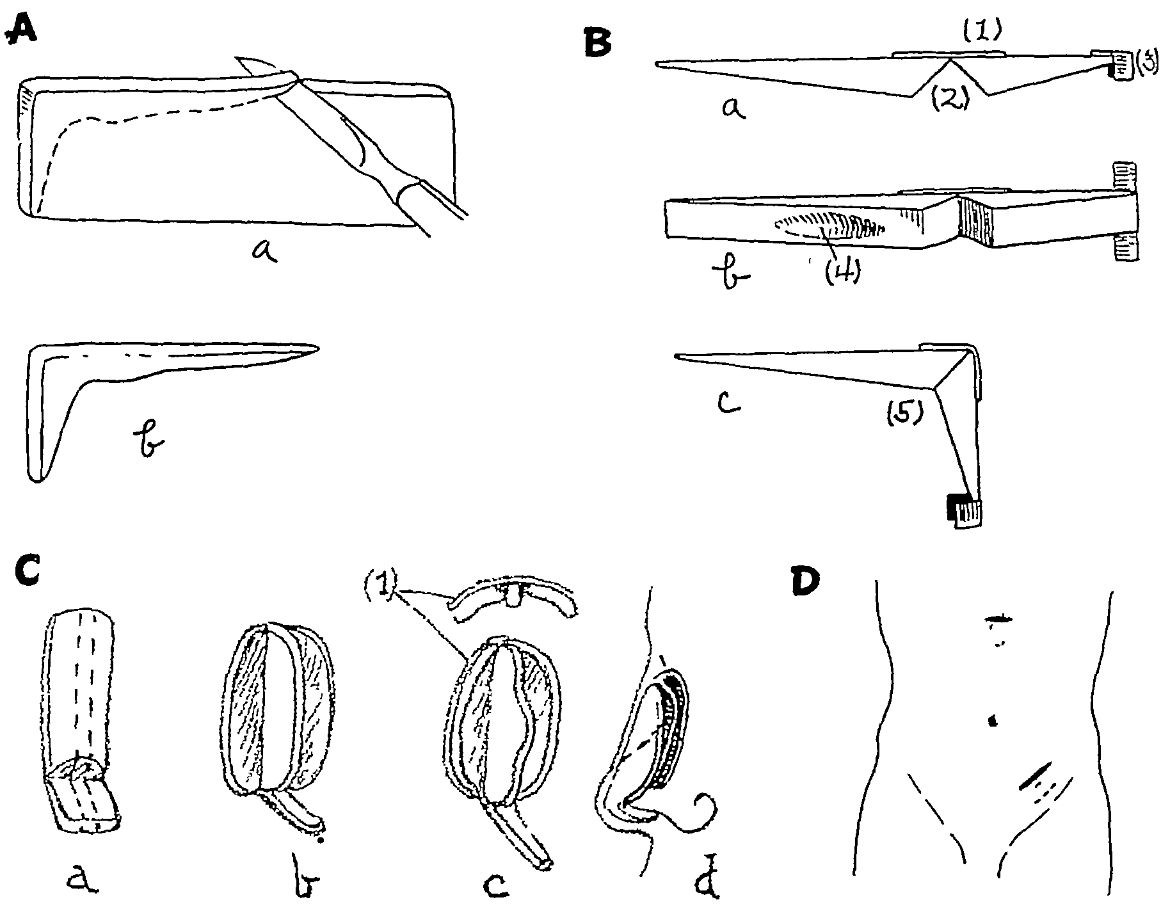


Fig 324 Modeling of angled graft *A*, graft with fixed angle *a*, L-shaped graft cut from block of cartilage 5 to 6 mm thick and of width equal to distance from nasal tip to anterior spine *b*, graft *B*, graft with perichondrial hinge *a*, perichondrium removed, except at *1*, to form hinge, and at *3*, for attachment to nasal spine *2*, wedge removed from cartilage, with apex toward perichondrium *b*, under surface of graft, showing groove *4*, to fit over nasal arch *c*, graft bent to form angle at *5* (Gillies) *C*, winged cartilage graft *a*, vertical flap turned down on perichondrial hinge Dotted line indicates incision to form wings *b*, wings turned out on perichondrial hinge *c*, graft modeled to conform to defect *1*, sectional view *d*, graft in place (Young) *D*, excess cartilage stored as reserve beneath kin of sternum or iliac fossa Dotted line shows cartilage

personnel then effect a change of raiment, freshly sterilized instruments are supplied, and the transplant is secured according the technic detailed on page 184

2 *Modeling of Transplant* The transplant is placed on a special side table with elevated edges, as a precaution against accidental slipping while it is being trimmed. If cartilage is used, the section is divided in half, one piece being stored as a reserve beneath the skin of the iliac fossa or beneath the right breast (fig 324-D), and the other shaped to conform with the normal contour of the nose in accordance with the pattern made on the cast, the thickest part of the transplant being shaped to fit the deepest part of the concavity The outer surface is trimmed so as to carry the dorsum in an

uninterrupted line from the frontal angle to the nasal tip The sides are shaped to merge with the lateral walls of the nose. In modeling the graft allowance must be made for the thickness of the overlying soft tissues, so as to avoid the creation of an unduly wide nose The upper end is tapered to a thickness of 2 to 3 mm , so that it will fit easily under the periosteal pocket previously made over the glabella and preserve the nasofrontal angle The lower end is tapered to a thickness of 3 to 4 mm , to blend with the tip All corners should be rounded to prevent irritation to the surrounding structures.

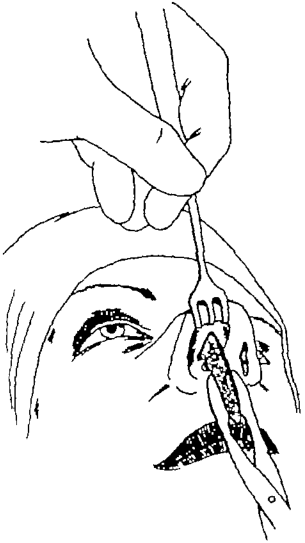


FIG 325 Introduction of cartilage graft, to furnish dorsal support.

If the tip as well as the dorsum requires support, some form of angled graft must be used. Gillies (76) cuts a single strip of cartilage long enough to reach from the glabella to the nasal spine (fig 324-B) After the proper point of angulation has been determined by measurement, a wedge is removed from the cartilage with its apex toward the perichondrium which has been left attached at this point, and the transplant is bent on its perichondrial hinge When inserted, the long limb will support the dorsum from the glabella to the nasal tip and the short limb will support the columella from the tip to the anterior nasal spine As an aid to fixation, some prefer to leave an additional tag of perichondrium on the distal end of the graft, to be sutured to the soft tissue around

In depressions involving but $\frac{1}{3}$ to $\frac{1}{2}$ of the dorsal length a better nasal contour and more satisfactory immobilization of the graft will result from shaving the entire dorsum down to an even plane and filling the scapha with a single long graft extending from the glabella to the tip of the nose, than from filling the cavity with a small graft

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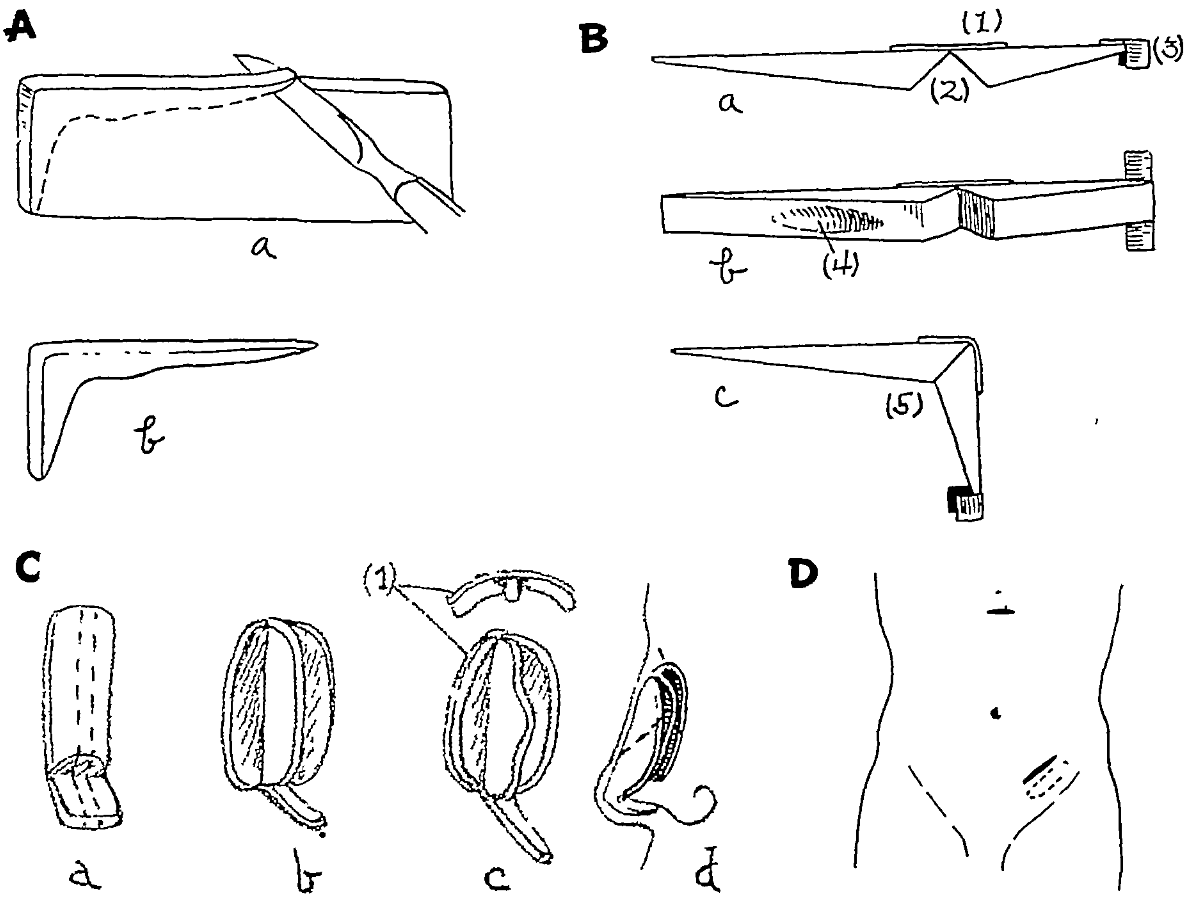

FIG 324 Modeling of angled graft *A*, graft with fixed angle *a*, L-shaped graft cut from block of cartilage 5 to 6 mm thick and of width equal to distance from nasal tip to anterior spine *b*, graft *B*, graft with perichondrial hinge *a*, perichondrium removed, except at *1*, to form hinge, and at *3*, for attachment to nasal spine *2*, wedge removed from cartilage, with apex toward perichondrium *b*, under surface of graft, showing groove *4*, to fit over nasal arch *c*, graft bent to form angle at *5* (Gillies) *C*, winged cartilage graft *a*, vertical flap turned down on perichondrial hinge Dotted line indicates incision to form wings *b*, wings turned out on perichondrial hinge *c*, graft modeled to conform to defect *1*, sectional view *d*, graft in place (Young) *D*, excess cartilage stored as reserve beneath skin of sternum or iliac fossa Dotted line shows cartilage

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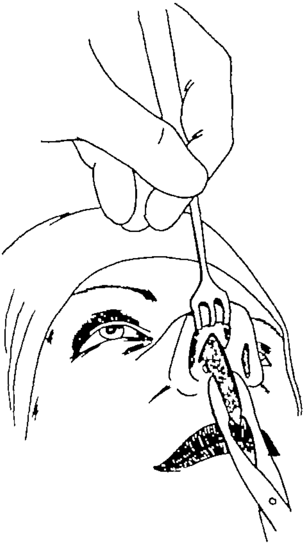

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the nasal spine. The objection to this graft is its tendency to break at the point of angulation

The writer employs a graft with a fixed angle. From the seventh, eighth, and ninth costal cartilages where they spread into a wide plaque a block of cartilage 5 to 6 mm. in thickness, and of a width equal to the distance from the nasal tip to the anterior

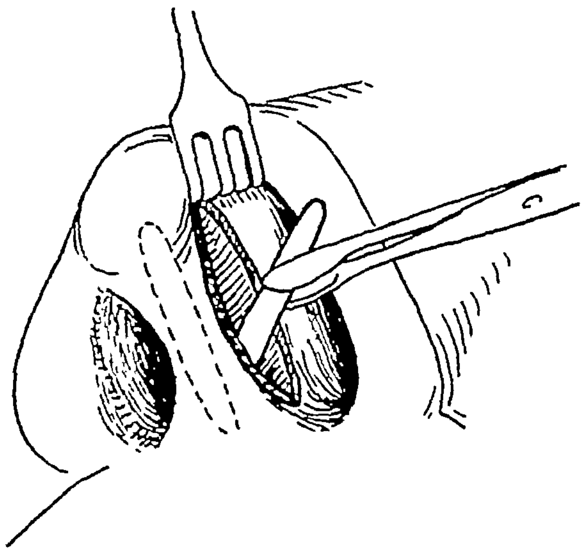
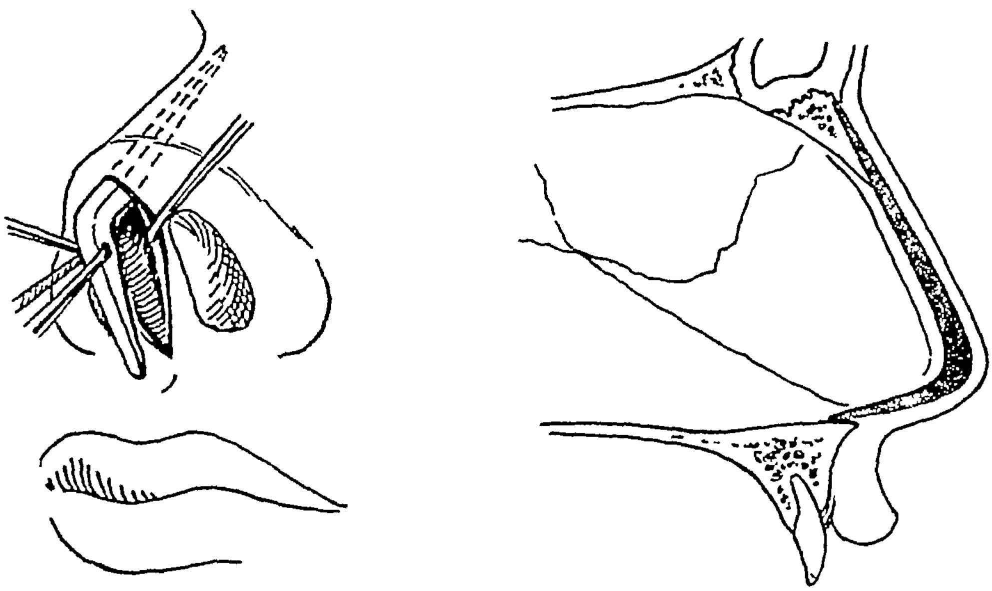


FIG 326 Introduction of cartilage graft, to furnish columellar support.



a b

FIG 327 Introduction of fixed angle graft, to furnish dorsal and columellar support *a*, graft introduced through central columellar incision *b*, sectional view, showing graft in place

nasal spine, is removed and placed on the modeling table From this block an L-shaped graft is cut, as shown in Figure 324-A This transplant is easily modeled and, due to its lack of perichondrium is not likely to curl

Cohen (30, 31) supports the tip by means of a separate strut of cartilage 2 to 3 mm thick passed between the two layers of the septal mucoperichondrium through an incision on the left side of the septum The graft is fixed in such a manner that

its lower end is supported on the nasal spine, while its upper end rests against the inner surface of the dorsal graft (fig 326)

Young (340) employs a *hinged* cartilage graft constructed in such a manner as to replace not only the dorsal edge of the septal cartilage but the lateral walls of the nose

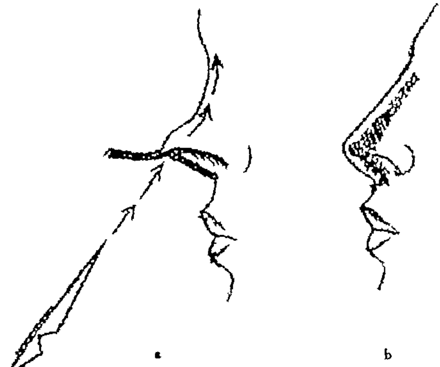


FIG. 328 Introduction of angled graft through opening made by upward reflection of columella. *a*, columella separated from attachment to philtrum and septum and elevated *b* graft introduced, and columella sutured back in place.

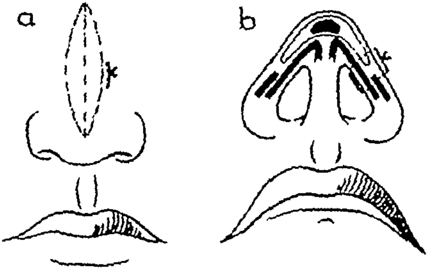


FIG. 329 *Immobilization of transplant by suture passed through full thickness of nasal wall. a* anterior view of suture. *b* sectional view (Lexer)

as well (fig 324-C) A section of costal cartilage is removed with its perichondrium intact. *Parallel longitudinal cuts are made almost to the perichondrium.* The wings thus formed, hinged on the perichondrium, are fractured outward. The median mass

the nasal spine. The objection to this graft is its tendency to break at the point of angulation

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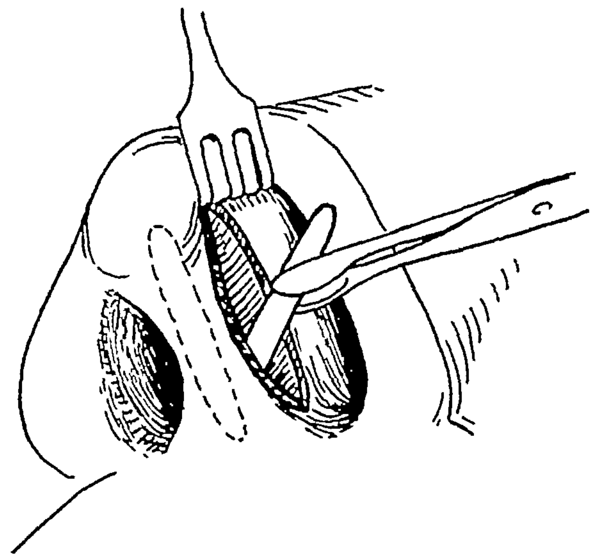
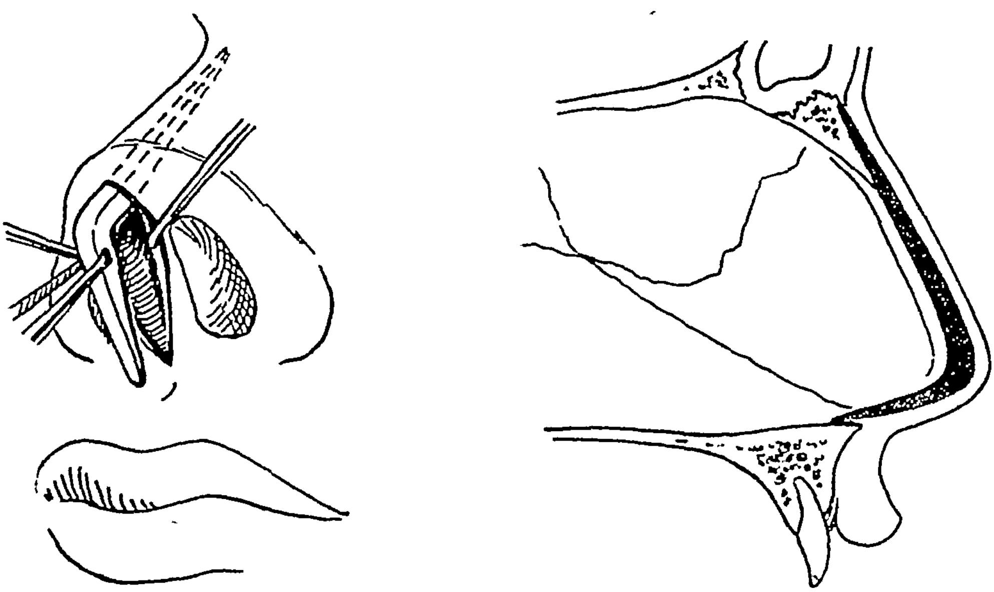


FIG 326 Introduction of cartilage graft, to furnish columellar support.



a b

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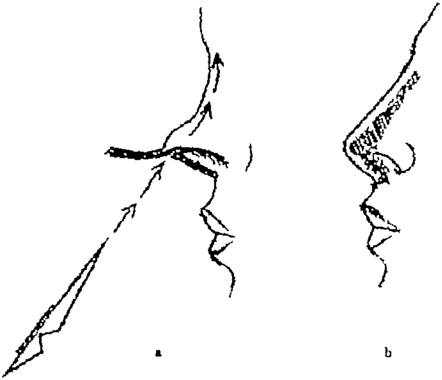


FIG 328. Introduction of angled graft through opening made by upward reflection of columella. *a* columella separated from attachment to philtrum and septum and elevated *b* graft introduced, and columella sutured back in place.

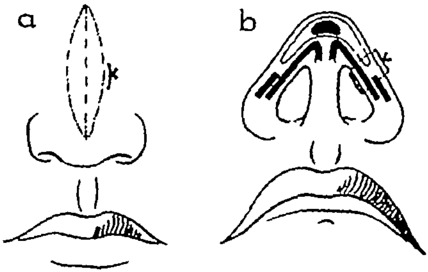


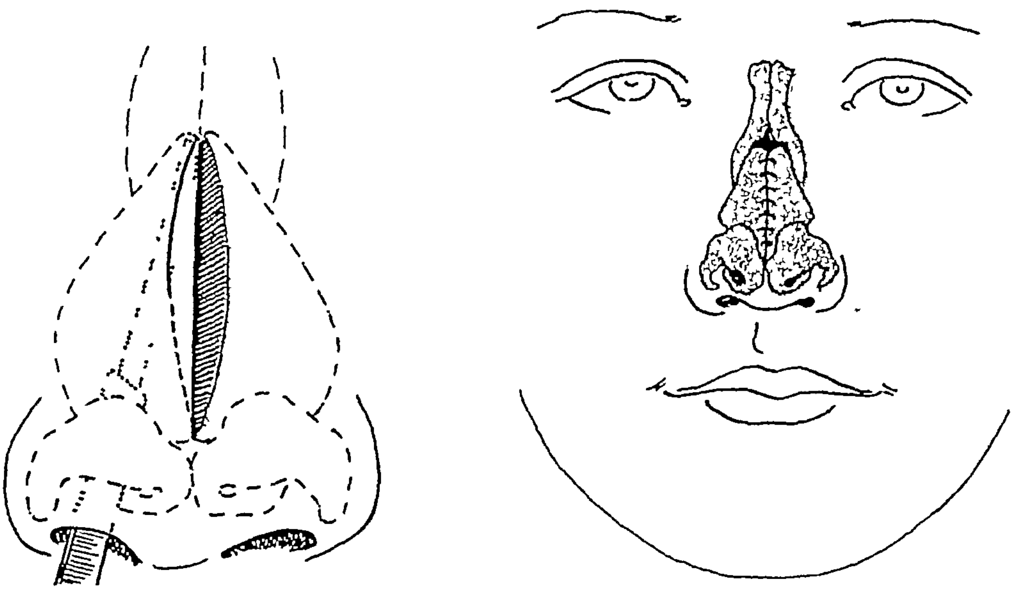
FIG 329 Immobilization of transplant by suture passed through full thickness of nasal wall. *a* anterior view of suture *b* sectional view (Lexer)

as well (fig 324-C) A section of costal cartilage is removed with its perichondrium intact. Parallel longitudinal cuts are made almost to the perichondrium. The wings thus formed hinged on the perichondrium, are fractured outward. The median mass

and the wings are then shaped to conform to a previously prepared model. The obvious objection to this graft is the difficulty in modeling and in its implantation

3 *Insertion and Immobilization of Transplant* After the transplant has been modeled, it is grasped with a toothed forceps and inserted into its bed through the initial incision, the margins of which should be widely retracted to prevent the graft from becoming contaminated by contact with them (fig 325) The danger of such contamination can be averted if the transplant is introduced through a speculum If the graft has been correctly shaped and its bed properly prepared, it will slip easily into place and immediately obliterate the defect Any further adjustment can be accomplished by external digital manipulation Finally, the wound edges are approximated with 2 or 3 fine silk sutures, and a dressing is applied and left on for a week Lexer prefers to immobilize the transplant by means of mattress-sutures passed through the full thickness of the nasal wall (fig 329)

Should the graft later become displaced or assume an asymmetrical position, the original incision is opened, the graft is separated from its fibrous tissue adhesions, and, without removal, is readjusted and immobilized



a b

FIG 330 Reduction of wide upper cartilaginous nose *a*, strip of cartilage and mucoperichondrium resected from anterior borders of upper lateral cartilages *b*, reduced cartilages fixed in place by sutures

DEFORMITIES OF UPPER CARTILAGINOUS VAULT

Wide Upper Cartilaginous Nose

A wide upper cartilaginous vault is due either to a hypertrophy or abnormal curvature of the upper lateral cartilages or to an undue thickening of the overlying soft parts Occasionally, the deformity is only simulated, being due to a lack of development of the nasal bones following trauma or disease in early childhood, the difference in proportion between the abbreviated nasal bones and the normal cartilages creating the impression of an excessive width of the latter Obviously, the "deformity" in such cases will disappear when the bony vault is elevated to its proper level (p 696)

The technic to be employed for the correction of this deformity will naturally depend

upon its underlying cause When the abnormal breadth is due to a thickening of the superimposed soft parts, the excess tissue is removed subcutaneously through an intranasal incision If the upper lateral cartilages are at fault, they are exposed through an intranasal incision and separated from their attachments to the septum If they are found to be abnormally wide, a strip of cartilage, together with its mucoperichondrium and of a size sufficient to correct the deformity is resected from their anterior borders. If unduly thick they are shaved down with a sharp scalpel. Should they be buckled, their spring is first broken by through and through cross-hatching After the cartilages have been reduced to the correct form and dimensions they are reapplied to the septum and immobilized by means of a splint (p 632) which is kept in position until organization has taken place (fig 330)

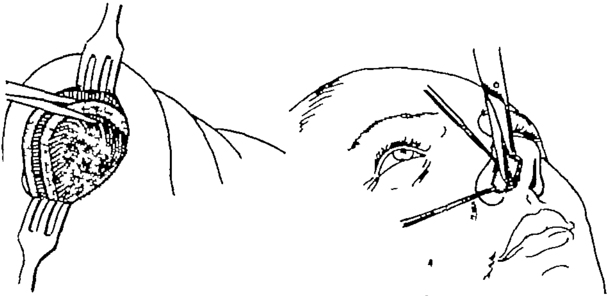


FIG 331. Shortening of abnormally long nose. *a* upper lateral cartilages separated from septum. *b* triangular section removed from septum with Mayo scissors For details, see text.

Long Nose

A long nose is usually associated with other irregularities of the nasal pyramid (p 667) and as a rule, results from excessively long septal and upper lateral cartilages Correction may be accomplished as follows An intranasal incision is made between the upper and lower lateral cartilages in the left vestibule Through this opening a scalpel is introduced and the skin is elevated by sweeping the instrument subcutaneously from the glabella over the dorsum to the lower edge of the septum The same procedure is carried out on the right side through a similar incision The septum is then completely separated from the columella, thus A blunt-end knife is passed through the left intranasal incision and carried down to the caudal end of the septal cartilage, brought out through the incision on the opposite side turned at right angles and made to cut through the membranous septum as far as the level of the nasal spine of the superior maxillae The upper lateral cartilages are then detached from the septum with a knife or a pair of scissors (fig 331) The tip of the nose is drawn upward with a blunt double-pronged retractor and the caudal margin of the septum exposed and steadied with a pair of toothed forceps A triangular section, with its base upward and its

apex at the nasal spine, is excised from the lower margin of the septum with a pair of straight Mayo scissors, the size of the section being regulated by the amount of shortening desired At this point the columella is pressed lightly against the resected septum to estimate the amount of reduction accomplished Should the nose still appear to be too long, an additional segment is removed When it has been reduced to the proper length, the columella is reattached to the septal cartilage by means of 2 heavy sutures passed through the entire thickness of both structures In order to compensate for the subsequent contraction that inevitably takes place along the line of union, these sutures should be placed obliquely, so that when tied the nasal tip will be tilted slightly forward and upward (fig 295) After these sutures have been tied, the upper lateral cartilages will be found too long for the shortened nose and protrude for a considerable distance into the vestibule Unless reduced, they will cause the lower half of the nose

FIG 332 Effect of shortening long nose

to appear unduly thick They are therefore excised with a pair of curved scissors placed flush with the intranasal incisions (fig 295) Finally, an adhesive strip is fixed along the columella, passed over the dorsum, and attached to the forehead (fig 261). The 2 sutures are removed on the sixth day (fig 332)

Short Nose

The operative correction of the abnormally short nose will be discussed in the section which deals with nasal deformities with loss of tissue

Sinuous Upper Cartilaginous Nose

A deflection of the cartilaginous nose may be secondary to a deviation of the nasal bones or due to a deviation of the upper lateral cartilages or septum In the former case

repositioning of the osseous dorsum will automatically restore the upper cartilaginous vault to a central position (p 690) In the latter the management will depend upon the nature of the deformity As a rule, one cartilage will present a broad concave surface and the other a narrow convex surface. In order to effect a correction, the walls must be mobilized and made equal Through the usual intranasal incision the skin over the cartilaginous dorsum is separated The cartilages are then detached from the septum, and with a pair of scissors a segment is removed from the broad side its size being gov

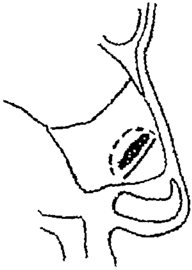


FIG 333 Repositioning of deflected septum. Solid line shows incision in mucoperichondrium on concave side. Dotted line, separation of membrane from cartilage. Shaded area, strip of cartilage removed to break spring of septum and permit its shifting to midline For details see text.

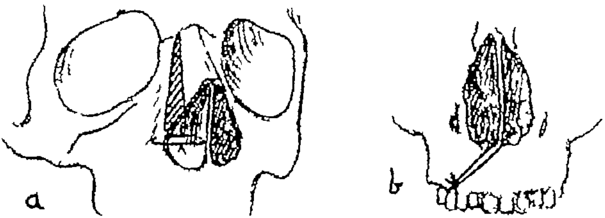


FIG. 334 Methods for immobilization following correction of deflected cartilaginous dorsum. *a*, triangle of cartilage removed from broad side. Septum immobilized by silk suture passed through its substance and carried through drill hole in pyriform process. (Joseph) *b* Freed septum anchored to bicuspid tooth with silver wire. (Blair) For details see text.

erned by the degree of deflection Following the resection, should one cartilage be found unduly thick, it is *shaved down to the proper thinness, and if buckled it is cross-hatched.* If the septum is deflected, the mucoperichondrium on its concave surface is separated and the cartilage cross-hatched at the angle of deviation If this procedure does not destroy the septal resiliency a strip of cartilage must be excised (fig 333) In so doing care must be taken to avoid cutting through the mucoperichondrium on the opposite side The cartilages and septum, thus treated, are then repositioned in their proper

relations and immobilized by means of a pressure dressing (p 677) Joseph immobilized the corrected nose by the use of a silk suture passed through the full thickness of the septum and carried through a drill hole made intranasally in the pyriform process (fig 334)

Deviated Septum

A dorsal and columellar deformity resulting from a displaced septum can be corrected only by a repositioning of the septum in the midline The corrective procedure to be adopted will depend upon the degree and location of the deflection (fig 335) In mild cases all that may be required to permit of the bringing of the septum into the midline will be shaving, cross-hatching, or removal of a strip of cartilage along the angle of deviation In more severe cases the desired results can be brought about only by recourse to a submucous resection

Technic of Submucous Resection 1 *Instruments* The instruments required for septal resection are (fig 336). a Ballenger swivel knife, a Bard Parker blade #11, several blunt and semisharp elevators of different curvatures, a Killian's nasal needle, a Thudicum's speculum, a Luc's nasal forceps, a strong punch forceps, a small gouge

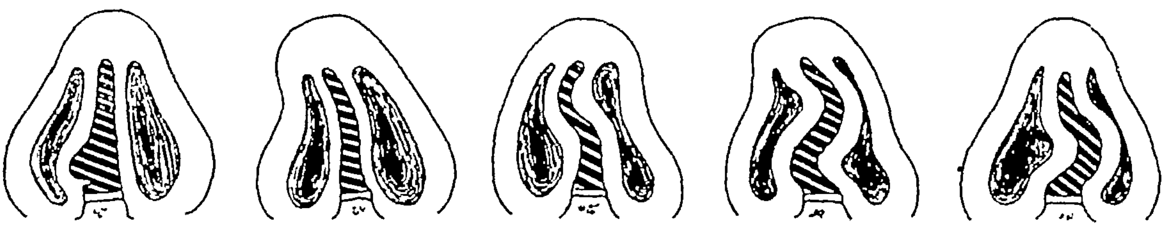


FIG 335 Common types of deflected septum (Barnhill)

and mallet for removal of bony spurs from the nasal spine and crest of the superior maxilla, and a good light

2 *Preparation and Anesthesia* The patient is prepared and draped for operation, and the nasal mucous membrane is anesthetized in the customary manner (p 669) Efficient hemostasis is of the greatest importance, since a continuous flow of blood renders the operation both tedious and difficult The injection of 1 5 to 2 cc of a 1 per cent solution of procain epinephrin under the perichondrium will aid not only in the control of hemorrhage, but also in the separation of the mucoperichondrium from the subjacent structures (fig 337)

3 *Incision* The nostril on the side of the convexity is exposed with a speculum, and the mucoperichondrium is incised with a small scalpel, care being taken to avoid penetration of the cartilage (fig 339) Many types of incisions have been advocated, and the choice will depend upon the location of the site of deflection Killian's curvilinear incision, made at the junction of the vestibular skin with the septal mucoperichondrium is the one most frequently employed (fig 338)

4 *Separation of Mucoperichondrium* An elevator is introduced through the incision, carried up between the cartilage and mucoperichondrium, and the latter membrane is freed from its attachments for some distance beyond the deflection by a sweeping motion of the instrument upward, downward, and backward (fig 340) It is essential that the separation be carried out in the proper cleavage plane, otherwise, bleeding will

be extensive and dissection difficult Evidence that the knife is in the correct plane is the appearance of the shiny cartilage and the ready separation of the membrane

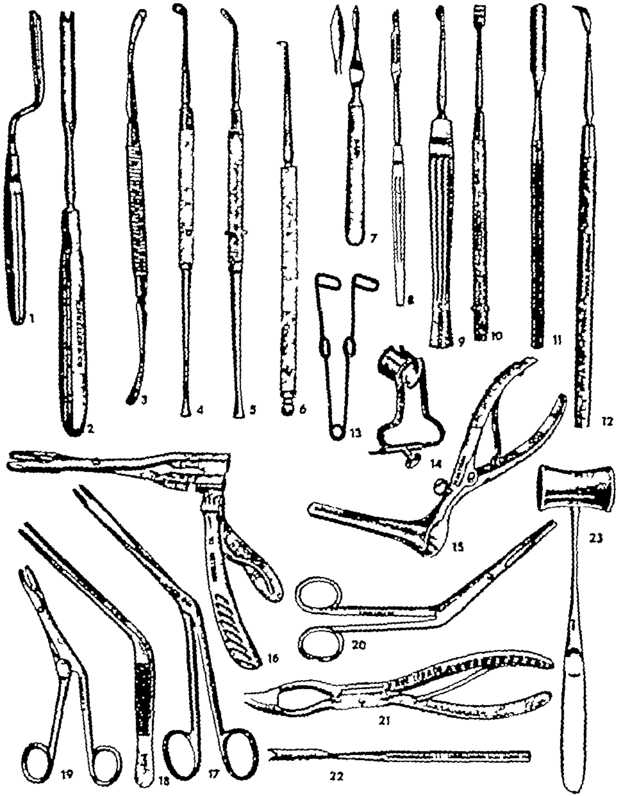


FIG. 336. Instrumentarium for submucous septal resection *1* bayonet swivel knife *2* straight swivel knife (Ballenger) *3–6* mucoperiosteal elevators (Freer) *7* cartilage knife. *8* Bard Parker knife. *9* septal knife *10* chisel *11* gouge chisel (Freer) *12* periosteal elevator *13* hairpin retractor *14* septal speculum (Nyles) *15* septal speculum (Killian) *16* septum gouge (Jansen Middleton) *17–18* nasal dressing forceps *19* bone-biting forceps (Hurd) *20* nasal scissors. *21* septal scissors *22* septum chisel *23* mallet

Even within the right plane, however, there is danger of lacerating the membrane at the site of a sharp bend or a spur or along a suture line. In the latter location it will be found advisable, therefore, to incise and raise the periosteum separately After the membrane has been completely liberated on the convex side, the cartilage is cut through, care being taken to avoid penetration of the mucoperichondrium on the opposite side (fig 341-a). As a precaution against such an accident, a finger is inserted into the other nostril while the incision in the cartilage is being made An elevator is then passed between the cartilage and the mucoperichondrium of the concave side

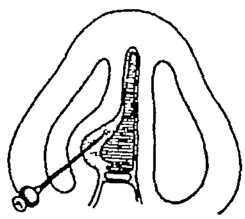


FIG. 337. Subperichondrial injection of anesthetic, to control hemorrhage and facilitate separation of mucoperichondrium (Barnhill)

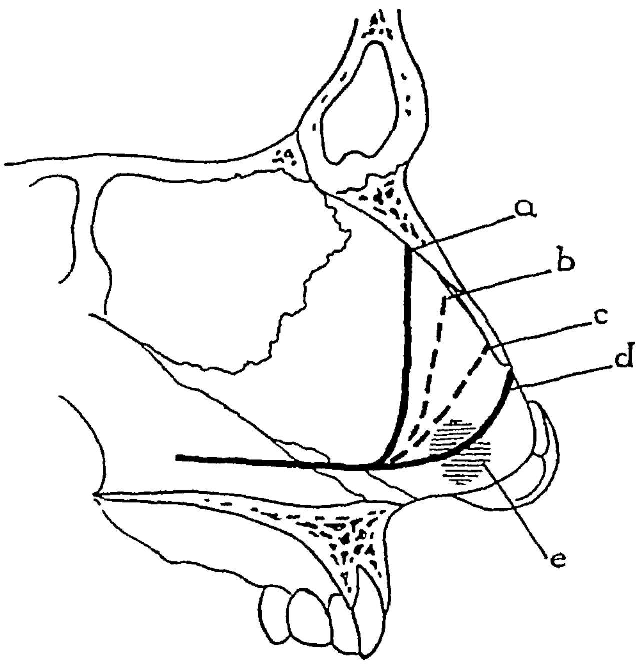


FIG 338 Types of incision employed for septal resection *a*, for posterior deviations *b*, for deviation of bony vault. *c*, Killian's incision *d*, for anterior deviations Shaded area shows most frequent site for perforation (Kirschner)

(fig 341-b), and the membrane is separated in a similar manner Since the mucoperichondrium on this side is more friable and more likely to be adherent, greater care must be taken in its separation to prevent tearing

5. *Management of Cartilage* With the cartilage thus freed on both sides, a speculum is introduced, the blades holding the two layers of mucoperichondrium apart and exposing the septal cartilage to full view (fig 342). The manner of dealing with the cartilage will depend upon the local findings In the case of children as much cartilage as possible should be conserved to prevent any interference with nasal development, and cross-hatching at the angle of deflection is usually sufficient In adults, on the other

Fig. 339 Basal view of incision. *a*, dotted line indicates incision in mucoperichondrium on convex side, through which perichondrium is elevated. *b* cartilage incised. Mucoperichondrium on concave side separated from cartilage.

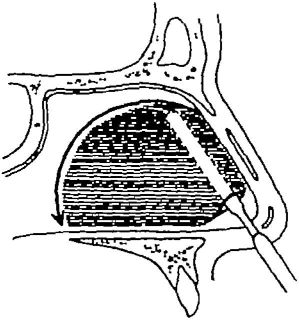


Fig. 340. Method of separating mucoperichondrium. Elevator introduced through incision and carried upward downward, and backward. (Barnhill)

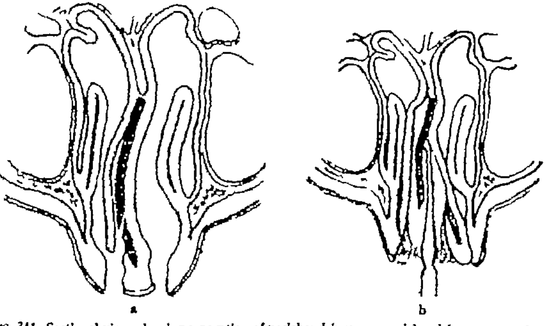


Fig. 341. Sectional view showing separation of perichondrium. *a*, perichondrium separated on one side, and cartilage incised. *b* perichondrium separated on opposite side. For details, see text. (Kirschner)

hand, cross-hatching usually fails to allow straightening of the cartilage, and the removal of a section of cartilage becomes necessary. This is most conveniently accomplished with a Ballenger swivel knife The instrument is introduced into a nick made in the anterior end of the cartilage The knife is first carried horizontally backward, just above the nasal crest, then upward, and finally downward and forward. The area of cartilage thus circumscribed is lifted out with forceps As previously stated, no more of the septum should be removed than is absolutely necessary for the relief of the obstruction, in any case sufficient buttress must be left anteriorly to prevent subsequent sinking of the dorsum (fig 343) A generous margin of cartilage must also be allowed to remain at the base for the support of the columella The nasal spine of the maxilla,

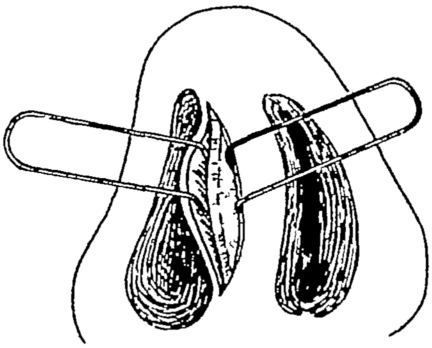


FIG 342 Exposure of caudal margin of septal cartilage with hairpin retractor prior to resection

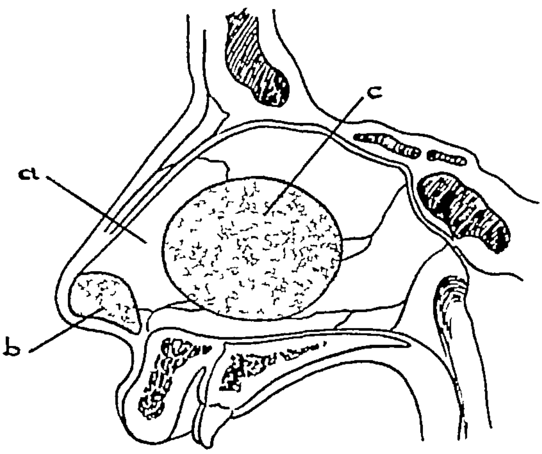


FIG 343 Submucous septal resection *a*, generous margin of cartilage left for dorsal and columellar support *b*, lower lateral cartilage *c*, amount of septum that can be safely removed

which forms a buttress for the septal cartilage, should be spared as much as possible After the removal of the deflected structures the septum is again inspected for evidence of future deformities If a bony portion is found to be deviated, it is cleared of periosteum with a bent Freer knife and removed with a strong punch forceps Spurs situated on the maxillary ridge are removed either with a cutting forceps or with a chisel and mallet

Finally, the space between the two layers of mucoperichondrium is douched with normal salt solution for the removal of all remaining detached fragments, such as blood-clots or loose pieces of bone and cartilage, and the layers are allowed to fall together The small incision is then closed by 2 or 3 sutures

6 *Dressing* An intranasal packing of xeroform gauze is applied against the septum to keep the membranes in apposition and prevent the formation of hematomata between the layers. As an alternative to the above packing two fingers cut from a sterile rubber glove and plugged with strips of gauze may be introduced into the nostrils The packing is removed in 24 hours and the patient is cautioned to refrain from blowing the nose for 3 to 4 days, and then only gently, one side at a time

Complications 1 *Hemorrhage* As the effects of the adrenalin begin to wear off, some postoperative bleeding is to be expected, and this can usually be controlled by the external application of ice compresses Should severe hemorrhage be encountered, however, the nasal cavity must be packed The packing should not be left in place longer than 24 to 36 hours lest infection result If an inflatable nasal bag is available, it will be found convenient for this purpose In case of obstinate bleeding it will be

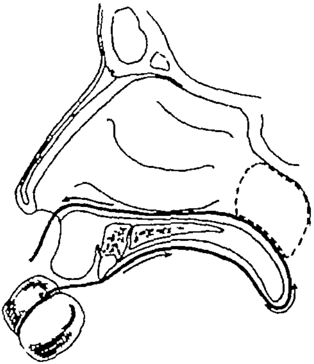


FIG 344 Packing of posterior nares Soft rubber catheter introduced into nostril made to appear in pharynx, and brought out through mouth Silk ligature holding tampon attached to end of catheter projecting from mouth. Catheter removed. Traction exerted on ligature to draw gauze tampon against posterior nares

necessary to pack the posterior nasal fossa as well as the nasal cavity (fig 344) Thompson describes the procedure for packing the posterior nares thus A sterilized sponge about the size of a tangerine orange is squeezed dry and tied around its center with a piece of tape leaving two free ends about 12 inches in length A soft rubber catheter is passed along the floor of the nose till it appears below the soft palate, when the end is seized with forceps and drawn through the nose To this end one of the tapes is made fast so that when the catheter is withdrawn from the nose the sponge is pulled into the posterior nasal fossa The other end hangs out of the mouth The two tapes are tied together over the upper lip

2 *Hematomata* Hematomata may collect between the layers of the mucous membrane the most common site being in the vicinity of the anterior portion of the septum Digital examination will reveal a swelling which is usually small, soft and fluctuant,

occasionally, however, it is so extensive as to force the septal mucous membrane against the lateral nasal wall and completely obstruct the nares on the affected side Small hematomata can be disregarded, as in time they become absorbed and leave only an insignificant thickening Large hematomata, on the other hand, require immediate evacuation, for if allowed to remain, they may either become infected or cause a thickening of the septum which may later interfere with respiration. Evacuation is best accomplished through the original incision The nasal cavity is then plugged with xeroform gauze to secure apposition of the membranes and prevent further bleeding. The packing is removed in 24 hours

3. *Septal Abscess* A septal abscess is usually secondary to an infected hematoma and is manifested by throbbing pain, a rise in temperature, and obstructed nasal breathing Inspection reveals a swollen, fluctuant mass The abscess requires prompt treatment, lest it lead to destruction of the septum, with subsequent perforation and loss

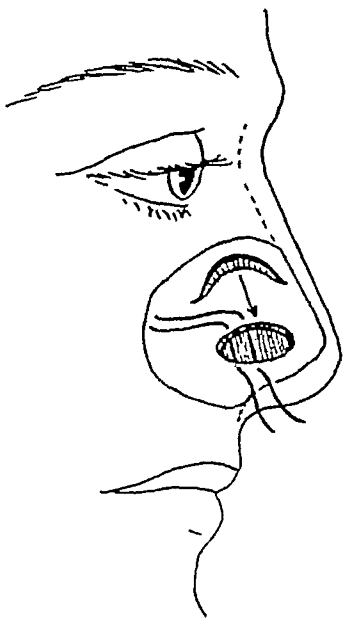


FIG 345 Repair of perforated septum Margins of defect pared Double-pedicled flap of mucosa raised contiguous to opening, shifted downward, and sutured to lower margin of defect. (Seiffert)

of dorsal support It is incised, all foreign particles are removed, and a small rubber drain is inserted

4 *Perforation of Septum* A perforation of the septum usually occasions little disturbance and requires no treatment, but should it cause discomfort from crustation, or give rise to hemorrhage or whistling respiration, treatment is indicated Crusts are softened with hydrogen peroxid and olive oil, and all granulations and bleeding areas are cauterized This procedure in itself is often sufficient to promote healing. The whistling respiration may be relieved either by enlarging the opening or by obliterating it Seiffert (283) operates thus· The margins of the defect are pared A double-pedicled flap of mucous membrane is raised contiguous to the opening The flap is shifted downward and sutured to the lower margin of the wound (fig 345). In the case of a fresh perforation Seiffert employs the tissue of the concha to close the opening The concha is denuded, and the raw area on the septum is approximated to it by

pressure with a tampon in the opposite nostril. After healing has taken place, the concha is cut through along its line of attachment with the septum (fig 346)

FIG. 346. Repair of fresh perforation in septum Concha denuded, and raw area of septum approximated to it by tampon in opposite nostril. After healing, concha cut through along line of attachment with septum. (Seiffert)

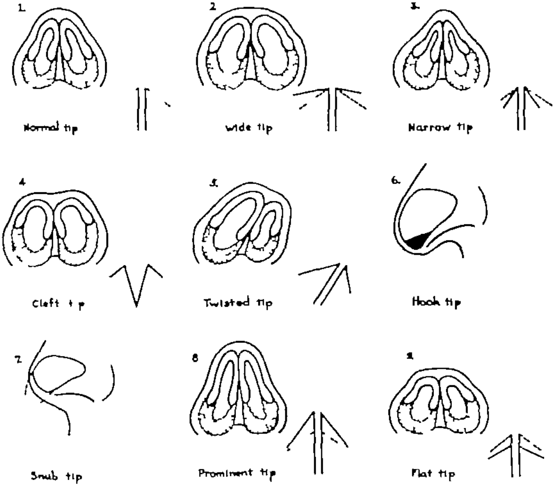


FIG. 347 Common deformities of lower cartilaginous vault. For details, see text.

DEFORMITIES OF LOWER CARTILAGINOUS VAULT

Normally, the *tip of the nose* forms with the upper lip an angle of approximately 90 degrees (fig 282) The angle may be abnormally increased by a deflection of the

occasionally, however, it is so extensive as to force the septal mucous membrane against the lateral nasal wall and completely obstruct the nares on the affected side Small hematomata can be disregarded, as in time they become absorbed and leave only an insignificant thickening Large hematomata, on the other hand, require immediate evacuation, for if allowed to remain, they may either become infected or cause a thickening of the septum which may later interfere with respiration Evacuation is best accomplished through the original incision The nasal cavity is then plugged with xeroform gauze to secure apposition of the membranes and prevent further bleeding The packing is removed in 24 hours

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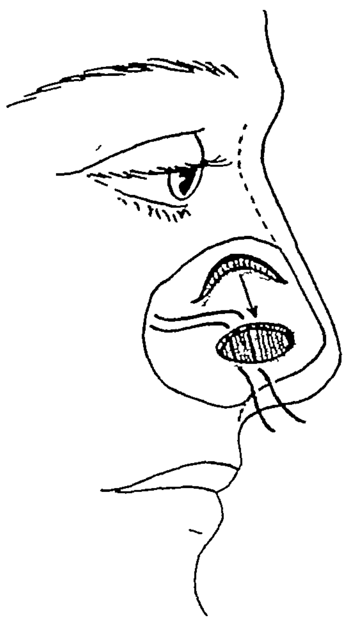

FIG 345 Repair of perforated septum Margins of defect pared Double-pedicled flap of mucosa raised contiguous to opening, shifted downward, and sutured to lower margin of defect (Seiffert)

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FIG. 346. Repair of fresh perforation in septum. Concha denuded, and raw area of septum approximated to it by tampon in opposite nostril. After healing, concha cut through along line of attachment with septum. (Seiffert)

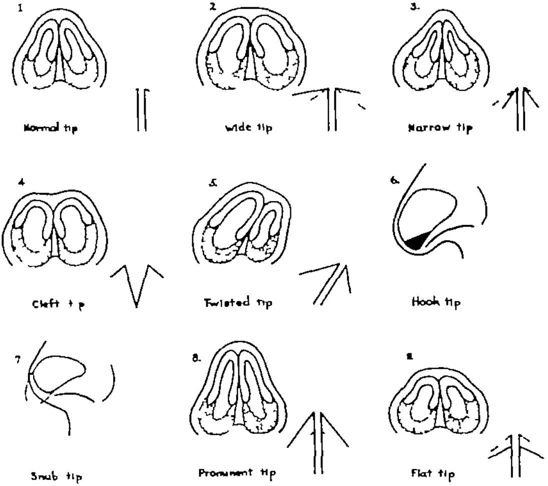


FIG. 347 Common deformities of lower cartilaginous vault. For details, see text.

DEFORMITIES OF LOWER CARTILAGINOUS VAULT

Normally, the *tip of the nose* forms with the upper lip an angle of approximately 90 degrees (fig 282) The angle may be abnormally increased by a deflection of the

lower lateral cartilages upward and backward, producing the so-called "retroussé nose", and, conversely, it may be decreased by a tilting of the tip downward and forward, resulting in the "hook nose" An increase in the normal length between the tip of the nose and the lip produces a prominent tip, whereas a decrease produces a depressed, or retreating tip The normal contour of the nasal tip is due to the graceful rounding of the angles of the lower lateral cartilages When these angles are excessively wide, a wide tip will result, when too narrow, a narrow tip, a separation of the angles will produce a cleft tip, distortions of the lower lateral cartilages or dislocation of the cartilages from one another give rise to a twisted tip, hypertrophy of the lower lateral cartilage is responsible for a bulbous tip, and atrophy for a flat tip, hypertrophy of one cartilage and atrophy of the other are evidenced by an asymmetrical tip (fig 347)

The *columella* may be too wide, producing narrow nostrils, too narrow, producing wide nostrils, too short, giving rise to a flat depressed tip, or too long, deforming the base of the nose by its redundancy When the medial crura of the lower lateral cartilages are abnormally wide, they force the columella below its normal level, giving rise to the condition known as "hanging septum" If the septum has been dislocated posteriorly from the spine of the maxillae, the columella is drawn back within the nose, if the septum has been displaced from its position in the median line, the columella will take an oblique course, and if the septum projects abnormally, it will force the columella downward An enlarged nasal spine and buckling of the medial crura of the lower lateral cartilages are also responsible for columellar deformities

The *alae* are subject to a wide variety of deformities They may be abnormally elevated or depressed either as a result of heredity or from cicatricial contraction following trauma or infection They may be collapsed, due to defective development or complete absence of the lateral crura, or to atrophy or paralysis of the alar muscles Occasionally, they are concave externally, causing the base of the nose to appear pinched Conversely, their convexity may be exaggerated, resulting in the typical rounded nostril of the negroid type Asymmetry in shape and position is common and is due to inequalities in the lateral crura

Disfigurements of the *nostrils* must obviously be caused by alterations in the structures which form their walls—namely, the columella, the lobule, the alae, and the base of the lip Thus, flaring nostrils result from abnormally convex alae, atresia from adhesions between the alae and septal walls The bases of the nostrils appear too wide when the alae are set too far apart, and horizontal nostrils occur when the columella is too short

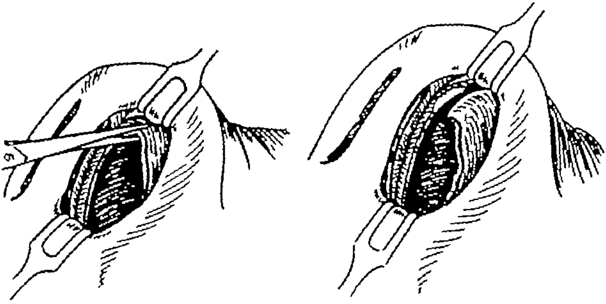
The following description of the technic employed for the correction of defects of the lower lateral cartilages will proceed on the assumption that the deformed structures have been exposed through the intranasal incision described on page 680

Deformities of Lobule

1 *Wide Tip* An excessively wide tip is a common nasal deformity and is usually due to a spreading of the angles of the lower lateral cartilages Correction is accomplished as follows Through the usual intranasal incision the skin is undermined over the entire lower half of the nose, so that later it may adapt itself more readily to the reconstructed framework The cartilages are exposed (p 680), and with a sharp knife or pair of scissors the angles are excised along their cephalocaudal length (fig 348) The amount of cartilage to be removed and the site of the excision are important

considerations. The size of the segments to be excised should be so gauged that their removal will produce an immediate result somewhat less pronounced than that ultimately desired, to compensate for the scar contraction which will eventually further narrow the tip. The site of excision should be at the apex of the angles, so that when the medial and lateral crura fall together, the lobule will be narrowed, but the projection of the tip will remain unaltered. Should the excision include too much of the crura, the lobule will be set too far back, and one deformity will have been supplanted by another. After the segment has been removed, the medial and lateral crura will fall together toward the midline, forming a more acute angle, the amount of reduction being equal to the combined width of the two sections excised.

In rare instances the excessive width of the lobule is due to hypertrophy of the soft tissues. In such cases the excess tissue is removed subcutaneously, preferably through Réthi's method of exposure (p. 684).



a b

FIG. 348 Reduction of abnormally wide nasal tip. *a* angle of lower lateral cartilage divided. *b* section of cartilage removed so that when crura fall together, resultant angle will be more acute. (Amount of narrowing of lobule will equal combined width of sections removed.) For details see text.

2. *Narrow Tip (Thin or Pointed Nose).* This is a condition wherein the angles between the lateral and medial crura are too acute.

If the deformity is associated with a long nose, a shortening of the nose (p. 707), followed by a division of the angles (p. 718) is usually all that will be required to overcome the disfigurement. When the columella has been reattached to the septum, the elevation of the tip which takes place will automatically cause the angles to separate and thus produce the necessary rounding.

In the absence of an associated long nose, the lower lateral cartilages are exposed, the angles divided, and the lateral and medial crura forcibly separated until the desired contour of the tip is attained. Fragments of the proper size are then snipped from the upper lateral cartilage and used to fill the spaces between the separated angles. The fragments of cartilage thus interposed will prevent a recurrence of the deformity from cicatrization during the healing process. The cartilages are maintained in their corrected relation by means of an intranasal splint or xeroform packing.

3. *Cleft Tip* Cleft tip is a deformity caused by an abnormal separation of the angles of the lower lateral cartilages All degrees of clefts are encountered, varying in extent from a slight dimpling of the lobule to a groove extending along the entire length of the dorsum and columella, producing what Trendelenburg called the "bulldog nose" In the latter case the nasal openings are flattened and enlarged, the root of the nose lies flush with the zygomatic arches, and the inner canthi are obscured by cutaneous folds

When the cleft is limited to the lobule, the usual intranasal incisions are made between the upper and lower lateral cartilages, and through these the skin is separated over the osseous and upper cartilaginous dorsum The nose is then transfixed by means of a blunt-end knife passed from one incision through the other, and the membranous septum is divided down to the nasal spine, the columella containing the medial crura being thus separated from the septal cartilage Through this exposure the medial crura and angles are freed from their attachments to the columella and lobule, approximated in the proper alinement, and secured in place by means of 2 fine catgut sutures passed as illustrated in Figure 349 Finally, the columella is reattached to the caudal extremity of the septal cartilage

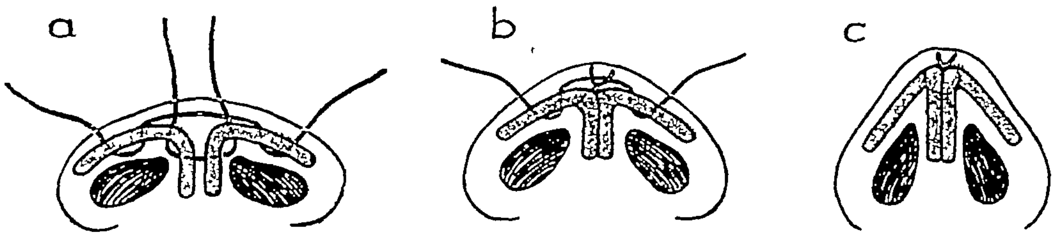


FIG 349 Correction of cleft tip *a*, lower lateral cartilages mobilized, and 2 sutures passed, to approximate separated angles *b*, effect of tying first suture c, result of tying second suture

Clefts involving the entire dorsum can be corrected only by a mobilization of the osseous and cartilaginous framework and approximation of the structures in the midline This is accomplished in the following manner· The soft tissues are elevated (p 679) The bony vault is mobilized by separation of the nasal bones at the internasal suture and division of the frontal processes of the superior maxillae The remaining attachments at the nasofrontal suture are fractured by digital pressure (p 674). The bones thus liberated are manipulated into the median line The upper lateral cartilages are then detached from the maxillae by division of the intervening aponeurotic attachments, and from the septum They are left attached to the nasal bones, however, otherwise, a horizontal depression will result at the juncture of the bones and cartilages The cartilages are then brought together in the median line and secured in place by means of 2 or 3 mattress-sutures passed through the full thickness of the nose Should the alinement show slight irregularities, small fragments obtained from the upper and lower lateral cartilages may be inserted to fill out the depressions Finally, the lower lateral cartilages are mobilized and adjusted The nose is splinted in the usual manner

Joseph (132) corrected a cleft nose deformity by excising the depressed central portion of the dorsum in the form of a wedge, mobilizing the frontal processes of the maxillae, and approximating the structures in the middorsal line

Dobrzaniecki (47) reports good results from the following operation which he per-

forms in three stages. In the first stage through an incision on the dorsum the skin is separated from its underlying structures as far as the pyriform opening An incision is made in the periosteum 1 5 cm. from the border of the opening, and through this opening the frontal process of the maxilla is cut through The same procedure is repeated on the opposite side. The mobilized bones are brought to the midline and held in place by means of a Joseph's brace At the second stage, carried out 4 weeks later, the hypertrophied skin on the dorsum is removed and an associated epicanthus if present, is corrected In the final stage 3 weeks later, the lower lateral cartilages are separated from their false relations through an incision on the base of the nose after which they are drawn into the median line and united to each other

The objection common to each of the above operations is the subsequent external scar which to the writer seems unnecessary

Fig 350 Correction of pendulous tip Triangle resected from upper and lower lateral cartilages, to create room for repositioning of lower cartilaginous vault upward and backward (Eitner)

4 *Pendulous Tip* A pendulous tip is characterized by a tilting downward of the lower lateral cartilages, causing the base of the nose to form with the upper lip an angle of less than 90° This disfigurement is usually associated with an elongated septal cartilage. Von Liebermann (170) describes a nose in which the tip reached almost to the upper lip and nasal respiration was possible only when the end of the nose was raised with the fingers

In order to increase the nasolabial angle the lower lateral cartilages must be repositioned upward and backward, and to create room for such an adjustment a triangle of cartilage must be resected from the septum. Obviously, the base of the triangle must lie on the dorsum and the apex be directed toward the nasal spine The technic for such an excision is as follows The skin of the nose is separated and the membranous septum divided in the usual manner The upper lateral cartilages are freed from their attachments to the septum for a distance equal to the base of the proposed triangle The septal cartilage is made to protrude through the left nostril, and a triangle is removed with a pair of straight stout scissors. The space thus created is

obliterated by fixing the columella to the septal cartilage with 2 strong silk sutures This automatically causes the lower lateral cartilages to tilt upward and thus restores the normal nasolabial angle Eitner creates room for the repositioning by removing a triangular section from the upper and lower lateral cartilages (fig 350)

5 *Prominent Tip* A prominent tip results from an abnormal distance between the tip of the nose and the lip Occasionally, a saddle-nose may cause the tip to appear unduly prominent, but in such a case the line from the apex of the nose to the lip will be found to be of normal length, and the illusion of prominence will disappear as soon as the depression has been filled out (p 696)

When the tip projects but slightly, the skin covering over the lower half of the nose is separated in the usual manner, and the columella is completely detached from

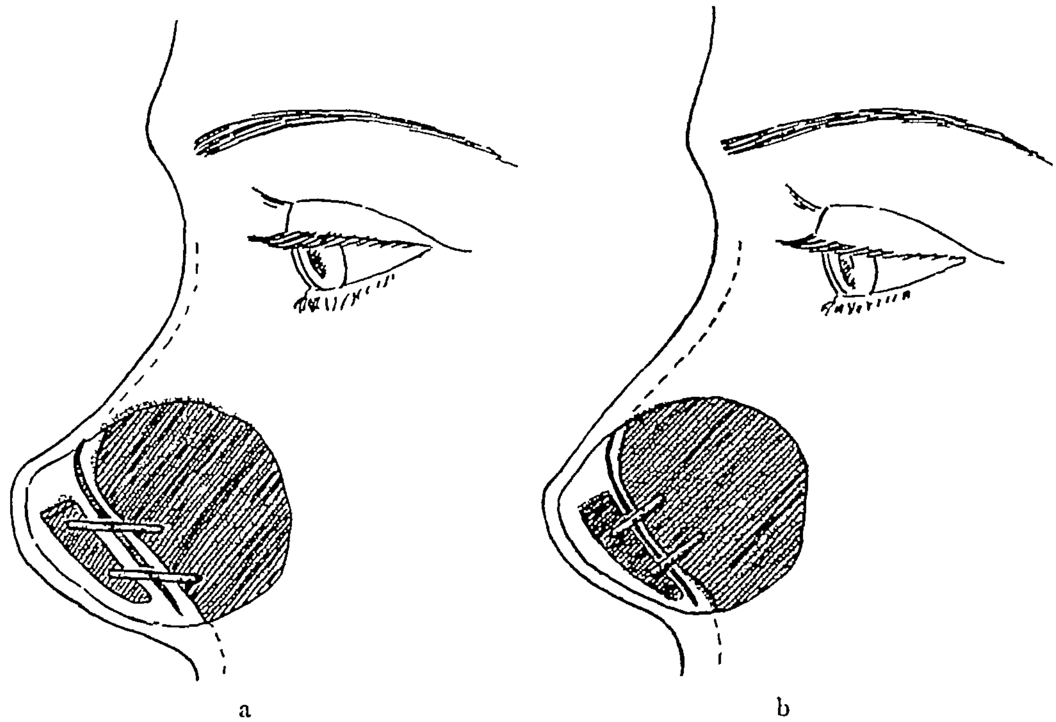


FIG 351 Reduction of slightly prominent tip *a*, solid line shows columella separated from septum Sutures passed obliquely through entire thickness of septum and columella *b*, when sutures are tied, mobile tip will be drawn backward on fixed septum

the cartilaginous septum The lower cartilaginous vault is then reset backward on the caudal edge of the septum and held in position by means of 2 strong braided silk sutures passing through the entire thickness of the cartilaginous septum and columella The same results may be brought about if the sutures are passed obliquely, as shown in Figure 351 When the stitches are tied, the tip will automatically be brought backward into its normal alinement In either case, the tip should be undercorrected 1 or 2 mm to compensate for subsequent scar contraction, and the patient should be informed that he is not to expect the desired results for several weeks The sutures are allowed to remain in place until healing is complete, which is usually on the fifth or sixth day

If the prominence is one of moderate degree, the above procedure will be inadequate In such cases the lower lateral cartilages must be exposed and resected The site of the excision and the amount of cartilage to be resected will be governed by the de-

formity If the tip is of normal width, the angles of the lower lateral cartilages are not disturbed. The resection is made through the elongated medial and lateral crura, and the intact angles are then reset backward on the shortened crura (fig 352) Ob-

a b

FIG. 352. Reduction of prominent tip with angles of normal width. *a*, shaded area, sections removed from elongated medial and lateral crura. *b* intact angles set back on shortened crura.

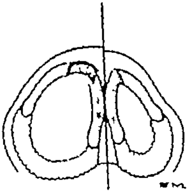
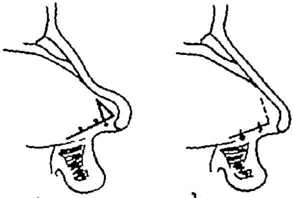


FIG. 353 Reduction of prominent tip with angles of excessive width (This requires resection of angles with as much of crura included as deemed necessary to set tip back.) Solid area indicates amount of cartilage to be removed. Solid line shows result when shortened crura are brought together Note reduction in width and prominence of resected side.



a b

FIG. 354. Reduction of prominent tip due to projecting septal cartilage. *a* cartilage to be removed outlined. Circles indicate position of sutures for approximation of columella to septum. *b*, result of resection and tying of sutures (Joseph)

viously the size of the section to be removed will depend upon the degree of prominence. If the lobule not only projects abnormally but is also excessively wide the angles themselves must be resected as much of the crura being included as is deemed necessary

to bring about the desired reduction (fig 353) When the shortened crura fall together, not only will the tip be narrowed, but it will be carried backward Occasionally, before the normal contour can be secured, it will be necessary to shave off an excessively projecting anterior margin of the septal cartilage (fig 354)

In a prominent tip associated with long narrow nostrils the membranous septum is shortened by the excision of a quadrilateral section Two parallel through-and-through incisions are made in the membranous septum, one along the upper, the other along the lower border of the medial crura To allow for subsequent readjustment of the vestibular skin to the shortened space, the lower incision should be somewhat longer

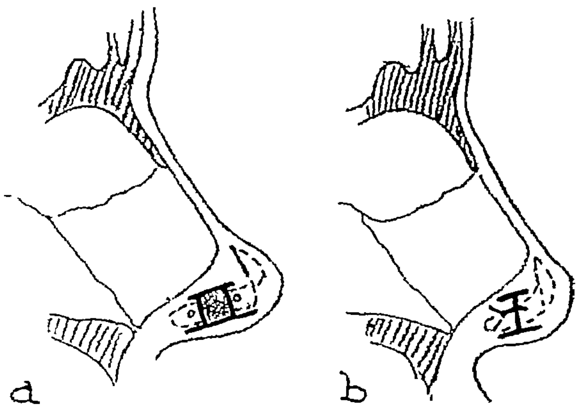


FIG 355 Reduction of prominent tip associated with narrow nostril *a*, quadrilateral section removed from membranous septum *b*, margins approximated For details, see text (Joseph)

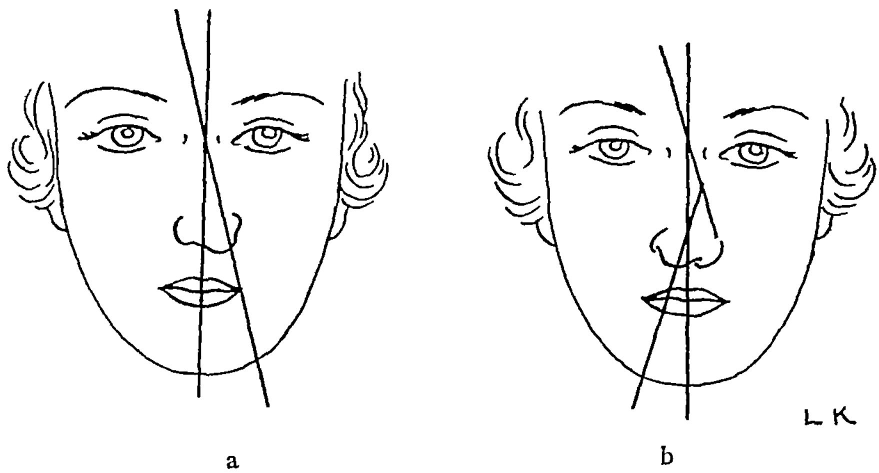


FIG 356 Method of determining deviation of tip Position of tip compared with line drawn through root of nose and midline of lip *a*, deviation to left, *b*, to right.

than the upper Between these incisions a rectangular section is removed (fig 355), and the margins of the wound are approximated Such closure will automatically effect a rounding of the alae, thus overcoming the narrowing of the nostrils As a rule, the columella adjusts itself to the reconstructed lobule, but in some instances it may require shortening (p 729)

6 *Twisted Tip* A deflected tip may be real, resulting from a displacement of the septal cartilage or a distortion of the lower lateral cartilages, or only apparent, due to a deflection of the osseous or cartilaginous dorsum The differentiation between a simulated and an actual deviation can be easily ascertained by a comparison of the tip of the nose with the midline of the mouth (fig 356)

Should the deflection be only apparent, a repositioning of the osseous and cartilaginous dorsum will eliminate the illusory deviation

When the lower cartilaginous vault is at fault, the treatment will depend upon the structures affected If the deflected tip is consequent upon a displacement of the caudal margin of the septum from its groove in the vomer, the deformity is corrected by bringing the septum into a median position and re-establishing it in its normal relation to the columella. Metzenbaum s (201) operation is an excellent solution to this problem. He proceeds in the following manner (fig 357)

"Instead of making the usual submucous incision within the nares, the incision is made along the free edge of the lower border of the dislocated septal cartilage where it presents in the nares The mucous membrane on the side of the septum in which the operation is being performed is not separated from the portion of the septum which is deflected, but the mucous membrane which comes through from the opposite nostril is separated from the cartilage up to the bend, or what I choose to call 'the

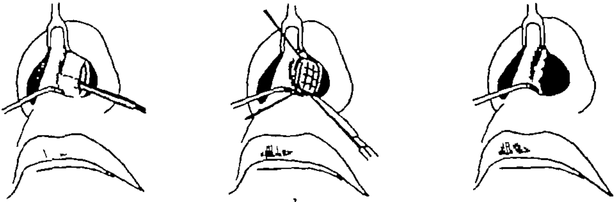


FIG 357 Reduction of twisted tip due to displaced septum. a, Incision made along free edge of dislocated border of septal cartilage. Mucoperichondrium on opposite side of nostril separated. b cartilage cross-hatched, leaving mucoperichondrium intact on one side c dislocated septum repositioned, and wound closed. For details see text. (Metzenbaum)

angle of deflection of the cartilage It is this angle in the cartilage which keeps the lower end of the septum deflected across the nares

"At the angle of deflection, the cartilage is incised to, but not through, the opposite mucous membrane, or it may be necessary to remove a narrow strip of cartilage parallel to the incision, so that the lower part of the cartilage can be straightened. The posterior border of the dislocated portion of the septum is separated from its attachments to the ridge along the floor of the nose but not separated from the mucous membrane in the nostril in which the operation is being performed. In order to force or spring the cartilage into the median line, one may find it necessary first to make a semblance of a groove in the vomer The tissues just back of the columella are separated for the reception of the lower end of the dislocated cartilage. These procedures usually permit the replacement of the dislocated lower portion of the septum into the ridge in the vomer into the columella, and underneath the drooping nasal tip, thereby raising the tip giving it support and rendering both nares patent.

'At the time of operation through the incision at the angle of deflection, any of the posterior part of the cartilaginous or bony septum or ridge may be corrected or removed as in the usual submucous resection The deflected lower part of the septal cartilage below or anterior to the angle of deflection is not removed but is always reset

in the median line to give support to the nasal tip and to re-establish patency to both nares "

Joseph (133) immobilizes the septum by passing a silk suture through the septum and pyriform process, as shown in Figure 334

If the deflection is due to asymmetry of the lower lateral cartilages, the normal contour can be restored by exposing the cartilages through the usual intranasal incision, shaving down the hypertrophied or buckled side, and transplanting the sections of cartilage thus removed into the opposite concave side If due to an asymmetry of the upper lateral cartilages, a triangular section is removed subcutaneously from the upper lateral cartilage on the broad flat side The septal cartilage is then replaced and united with the reduced upper lateral cartilage by means of mattress-sutures (306)

7 *Flat or Retracted Tip* The flat tip is a congenital or acquired deformity characterized by a shortening of the distance between the tip of the nose and the lip The deficient projection may be relative, owing to an abnormally high dorsum, the disproportion creating the impression of flatness In such cases reduction of the dorsum to the normal profile height (p 685) will automatically eliminate the illusion of a tip deformity

Absolute flattening of the tip may be due to (1) a shortened columella which pulls the nasal tip backward, (2) a deficient projection of the lower lateral cartilages, or (3) a lack of support following (a) a faulty submucous resection in which the lower anterior part of the septal support was inadvertently destroyed, (b) a fall on the face in which the cartilaginous septum was fractured and its lower end dislocated from the groove in the vomer, or (c) septal abscesses or necrosis As a result of the lack of support the tip droops, the columella becomes redundant, and the alae and nostrils are flattened

The correction of this deformity will obviously depend upon the parts affected If the septum is at fault, the depressed nasal tip can be raised and maintained only by a re-establishment of the dislocated septum in its normal place or by the introduction of a columellar strut (fig 326) If the columella is too short, it must be lengthened (fig 359) Should the retraction be due to displacement of the caudal margin of the septal cartilage, an incision is made along the free edge of the dislocated cartilage where it projects into the nares The mucoperichondrium on the side of the convexity is separated in a manner similar to the method employed for a submucous resection (p 710), and the angle of deflection, thus exposed, is cross-hatched throughout the entire thickness of the cartilage, care being taken, however, to avoid perforation of the mucous membrane of the opposite side (fig 357) Should cross-hatching prove insufficient to permit of the bringing of the cartilage to the median line, a strip must be removed (fig 333) With the spring of the cartilage destroyed, the lower border of the septum is separated from its abnormal attachment along the floor of the nose Here also the mucous membrane on the side opposite the incision must be kept intact A groove is then fashioned in the vomer and a bed made in the columella for the reception of the dislocated septal cartilage The mobilized cartilage, hinged on the cross-hatched portion or on the space left after the resection of a strip of cartilage, is shifted to the median line and secured in place by means of sutures passed through the mucoperichondrium and soft tissues of the columella on the side of the incision The repositioning of the septum will automatically raise the depressed tip to a normal level and furnish support to the columella

If the flatness of the tip is due to a lack of septal support and the nose is abnormally long, the operation designed for shortening the nose, described on page 707, will simultaneously effect a correction of both deformities. Following the reduction the shortened septal cartilage will furnish adequate support for the repositioned tip (fig 358) If,

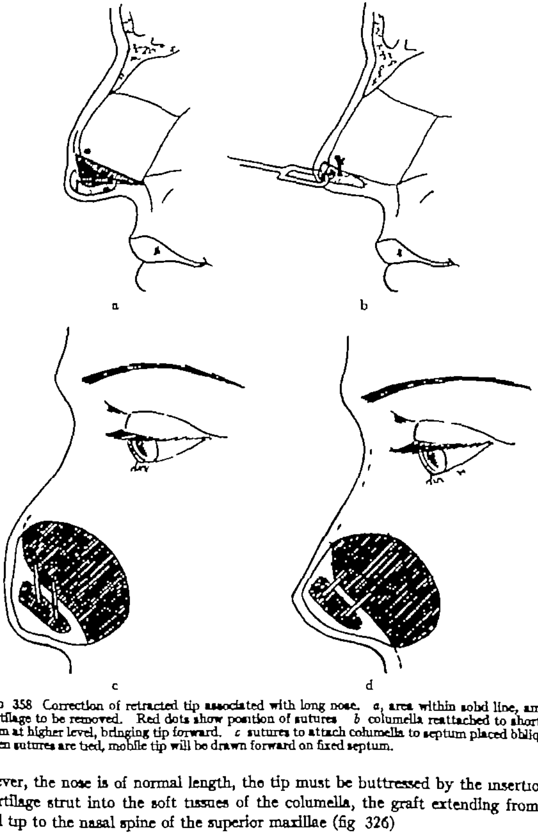


FIG 358 Correction of retracted tip associated with long nose. *a*, area within solid line, amount of cartilage to be removed. Red dots show position of sutures *b* columella reattached to shortened septum at higher level, bringing tip forward. *c* sutures to attach columella to septum placed obliquely *d*, when sutures are tied, mobile tip will be drawn forward on fixed septum.

however, the nose is of normal length, the tip must be buttressed by the insertion of a cartilage strut into the soft tissues of the columella, the graft extending from the nasal tip to the nasal spine of the superior maxillae (fig 326)

Should the flat nasal tip be the result of a shortened columella, the latter is lengthened

at the expense of the width of the upper lip The columella is separated from its septal attachment An incision is carried down through the skin on either side of the philtrum for a distance sufficient to secure the necessary lengthening, the two incisions meeting below in a point, as shown in Figure 359 The section of skin thus outlined is separated from its underlying attachments The lengthened columella is reattached to the septum and to the lip at a higher level The margins of the triangular defect in the lip are then approximated from below upward

Occasionally, it will be found that the flatness of the tip is due to a receding upper lip which carries the columella too far posteriorly and drags the tip of the nose with it Under such circumstances, the release of the base of the nose from the nasal spine will permit the columella and lobule to be brought forward into their normal positions The columella is freed from the septum throughout its entire length, and the soft tissues are separated from the nasal spine The tip is then advanced to the desired level, and the columella is fixed in its new relation to the septum by means of 2 or 3 silk sutures These are removed in 5 or 6 days when adhesions will have taken place Slight overcorrection is advisable, as the subsequent contraction will depress the tip 1 or 2 mm

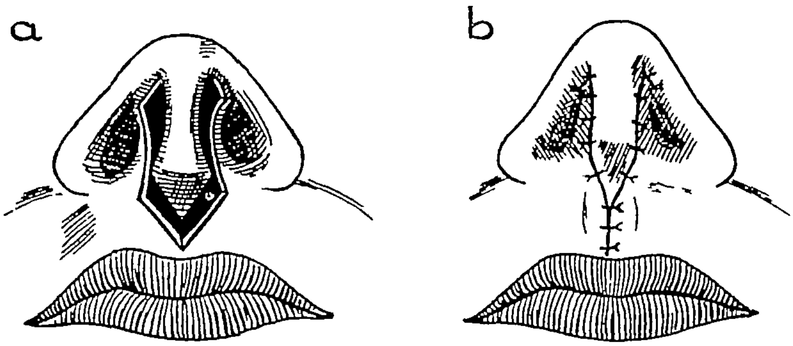


FIG 359 Correction of retracted tip due to shortened columella *a*, columella separated from septal attachment Incision prolonged through skin on either side of philtrum for distance sufficient to secure necessary lengthening of columella *b*, lengthened columella reattached to septum and lip at higher level Remaining wound closed

8 *Retroussé Tip* This disfigurement is characterized by an upward and backward tilting of the tip of the nose, resulting in a widening of the nasolabial angle The condition may be congenital, due to a short septum or an abnormal upward tilting of the lower lateral cartilages, or acquired from cicatricial contraction of the covering, framework, or lining of the nose following trauma or disease

The method to be adopted for the correction of the deformity will depend upon its underlying cause If the upward tilting of the tip is only apparent, due to a scapha on the dorsum, the obliteration of the cavity with a cartilage implant (p 700) will eliminate the illusion If the lower lateral cartilages are tilted upward and the septum is of normal length, the cartilages are first freely mobilized and then reset in such a way as to restore the nasolabial angle

When the upward tilting is associated with an abnormally short septum, correction may be accomplished as follows (fig 360) The soft tissues covering the nasal pyramid are separated in the manner already described on page 679 The upper cartilaginous vault is freed from its attachments to the septum, nasal bones, and maxillae, and thus completely mobilized The whole cartilaginous vault is then

slipped downward on the septum and fixed at the desired level by means of 2 mattress-sutures passing through the full thickness of the nose. A small pad of xeroform gauze is placed under the suture to prevent undue pressure on the skin. The resultant slight depression on the dorsum between the bony and cartilaginous vaults can easily be overcome by the subcutaneous implantation of a piece of cartilage obtained either from the upper lateral cartilages or from the back of the ear. The usual splint is applied and the sutures are removed in 48 hours.

A retroussé nose due to a loss of tissue is discussed in the section devoted to nasal deformities with loss of tissue.

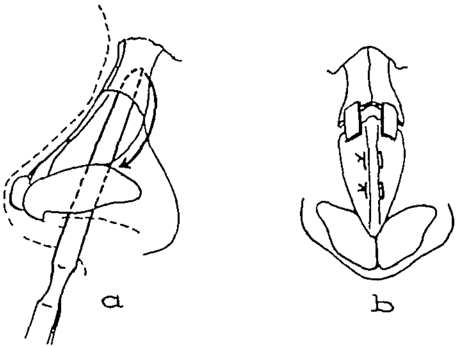


Fig 360 Correction of retroussé tip associated with abnormally short septum. *a* upper cartilaginous vault freed from its attachments. *b* entire vault slipped downward on septum and fixed at desired level by 2 mattress-sutures passed through full thickness of nose. Cartilage implants in place, to eliminate depressions between bony and cartilaginous vaults. For details see text.

Deformities of Medial Wall

1 *Abnormally Long Columella* An abnormally long columella is usually associated with an unduly prominent tip (p 722) and its reduction is carried out at the same time that the tip deformity is corrected. The columella is freed throughout its entire extent from its attachment to the septal cartilage and is cut through at its junction with the philtrum. The excess tissue is excised, and the shortened columella is re-attached to the septal cartilage and philtrum in its new relationship.

2 *Abnormally Short Columella* This deformity is always associated with a flat or retracted tip. The columella is lengthened at the expense of the width of the lip. The details of the technic are given on page 726.

3 *Abnormally Wide Columella* A wide columella is due either to hypertrophy of the soft tissues, or to separation of the medial crura of the lower lateral cartilages. The latter condition is recognizable by a visible cleft in the columella.

If the thickening is due to hypertrophy of the soft tissues, and the medial crura are in their normal relationships, the excision of an oval section of tissue from the external

aspect of the columella, followed by an approximation of the margins, will correct the deformity (fig 371) This method, however, has the disadvantage of leaving an external scar To eliminate this objectionable feature, the writer operates as follows: An intranasal incision is made on each side of the columella, parallel to its long axis Through these incisions the excess subcutaneous tissue is excised The redundant skin is then removed, and the two small intranasal wounds are sutured

If the excessive width is due to a separation of the medial crura, the crura are freed (p 680), the intervening connective tissue is excised, and the crura are approximated in the midline by means of 1 or 2 fine catgut sutures

4 *Oblique Columella* An oblique columella usually results from cicatricial contraction following ulceration Correction is accomplished by recourse to a Z-plastic operation By a transposition of the flaps the columella is brought into the median line Figure 361 is self-explanatory

5 *Hanging Septum* This is a deformity in which the mobile septum shows a dependent convexity It may be due to (1) excessive width of the medial crura, (2)

FIG 361 Correction of oblique columella by Z-plastic operation *1*, obliquity at philtrum *a*, line of incision *b*, flaps transposed *2*, obliquity at lobule *a*, line of incision *b*, flaps transposed.

an abnormal projection of the septal cartilage, (3) an unduly long columella, or (4) some combination of these conditions It is important that the cause be diagnosed, as the methods of correction are entirely different

When only the medial crura are at fault, correction is best accomplished by the removal of a crescentic section from the full thickness of the mobile septum A better wound will result if all the structures are cut through with a single stroke of the knife The crescentic aperture which remains is obliterated by the approximation of its margins with fine silk sutures (fig 362)

A hanging septum resulting from a protrusion of the septal cartilage constitutes one type of "long nose" deformity, and its correction has already been described (p 707) When it results from a projection of the septum and a widening of the medial crura, the two defects are corrected at the same time, but by individual procedures First, the nose is shortened according to the technic given on page 707 Then, through the incision in the membranous septum the medial crura are exposed, and from their upper edges a segment of cartilage of a size sufficient to overcome the deformity is excised Crescentic segments of skin are then removed from both sides of the membranous septum, and the reduced columella is reattached to the septal cartilage

6 *Abnormally Wide Nasolabial Angle* In this deformity the angle between the base of the nose and the lip (normally 90°) is either increased or obliterated The

defect is due either to an overdevelopment of the anterior nasal spine of the maxillae, to an excessive amount of subcutaneous tissue, or to a combination of the two

Correction is accomplished as follows The columella is separated from its attachment to the septal cartilage (fig 363) If the spine projects unduly, the excess bone is chiseled away Any superfluous subcutaneous tissue is excised The columella

FIG. 362 Correction of hanging septum. *a* outline of incision. *b* crescentic section of skin and cartilage excised from full thickness of mobile septum. *c* crescentic opening obliterated by approximation of margins with fine silk.

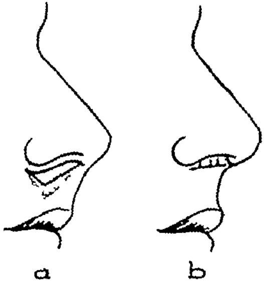


FIG 363 Reduction of abnormally wide nasolabial angle. *a* columella separated from its attachment to septum down to nasal spine. Dotted line indicates extent of undermining. Projecting nasal spine chiseled away and excess subcutaneous tissue removed. *b* columella set back and resutured to septum.

is then set back and resutured to the septum Pressure is obtained by carrying a piece of adhesive tape across the nasolabial angle and attaching it to the cheek above on both sides. The excess tissues may also be removed intra-orally through a horizontal incision along the gingivolabial junction (fig 364)

7 *Retracted Columella* A retracted columella is the reverse of a hanging septum and may be due to fractures and displacement of the septum or to cicatricial contraction following ulceration

If the retraction is due to a displacement of the septal cartilage, the deformity is corrected by mobilizing the cartilage and repositioning it in the midline (p. 710). If it is the result of cicatricial contraction, the columella may require lengthening or support In the latter case a morsel of cartilage taken from the ear and implanted into a prepared bed in the columella serves the purpose

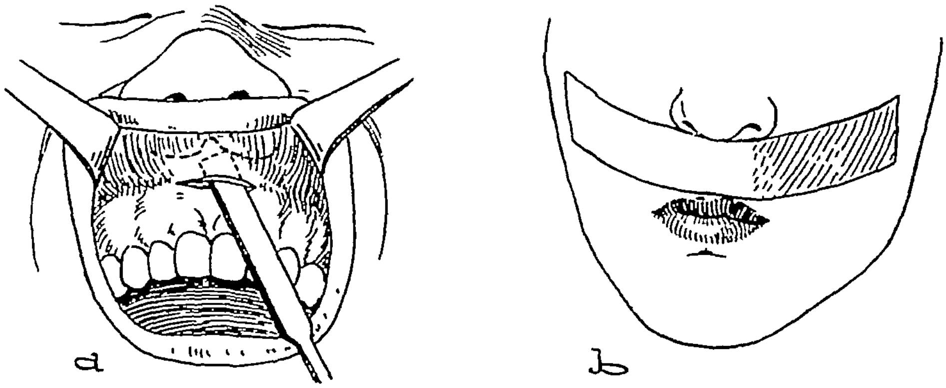


FIG 364 Reduction of abnormally wide nasolabial angle *a*, horizontal incision made in gingivolabial fornix Skin undermined, and nasal spine removed with chisel *b*, parts held in corrected position by strip of adhesive tape placed across nasolabial angle

FIG 365 Correction of abnormally convex alae Solid lines indicate semilunar sections of tissue to be excised from full thickness of alae Following excision, reduced alae reattached to cheek (Weir-Joseph)

Deformities of Lateral Wall

1 *Abnormal Convexity of Alae* Abnormally convex alae are usually due to an abnormal curvature of the lateral crura and are evidenced by wide nostrils of the negroid type

When the greatest curvature lies in the vicinity of the alar-facial junction, some modification of Weir's operation (fig 365) is applicable Joseph's technic follows One blade of a pair of curved scissors is introduced into the vestibule, and the other blade is fitted exactly in the alar-facial fold The closing of the scissors will completely separate the ala from the cheek A semilunar section of tissue of the required size, usually about 4 to 5 mm at its base, is excised from the full thickness of the ala The reduced ala is reattached to the cheek by means of 2 or 3 horsehair sutures The writer, to do away with the external scar, removes the wedge of tissue intranasally (fig 366).

When the convexity is anterior, the crura are exposed intranasally (p 680), and a section 4 to 5 mm wide is removed from the area of maximum convexity With the spring of the cartilage thus broken, the convexity will automatically disappear

2 *Collapse of Alae* Collapsed alae is a condition wherein the alae are too closely approximated to the columella, resulting in an interference with breathing With each inspiration the alae are drawn toward the septum and the intake of air is accompanied by a whistling sound. The defect may be due to paralysis of the alar muscles, absence of the lateral crura, or a reversal of their normal curvatures The "pinched nose" appearance is characteristic.

When an absence of the lateral crura is responsible for the condition, the supporting structures must be replaced Grafts to be used for this purpose may be secured from the upper lateral cartilages or from the helix. If ear cartilage is employed, it must be shaved down to the required thinness. In either case it is advisable to leave the perichondrium attached to the surfaces which are to face the vestibule, so that when contraction takes place, the ensuing curvatures will assist in maintaining the patency

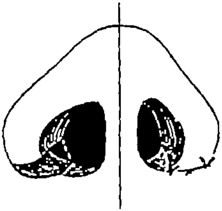


FIG 366 Correction of abnormally convex alae. Wedge-shaped section of tissue removed intranasally as indicated by shaded area. Solid line on right shows effect of approximation of wound margins

of the nostrils A bed is prepared through an intranasal incision, and the morsel of cartilage is implanted in the usual manner

If the lateral crura are well developed but the curves reversed—i e , if the concavity is external and the convexity internal—the lower lateral cartilages are exposed intranasally (p 680) and their angles divided The lateral crura are then removed and reinserted in a transposed position so that the concavity which previously faced outward will now be directed toward the vestibule Walsham corrected the condition thus From the anterior portion of the septum he raised a flap 3 mm. wide and 1.5 cm long, with its pedicle lying on the nasal dorsum, rolled it up, and fastened it to a prepared bed beneath the apex of the vestibule (fig 367)

3 *Abnormal Elevation of Alae* An abnormal elevation of the ala may be congenital, in which case the deformity is usually bilateral, or it may be acquired as the result of cicatricial contraction in which event it is as a rule unilateral

The method of correction will vary in accordance with the cause When both nostrils are equally elevated and the condition is associated with a long nose, a shortening of the nose (p 707) will equalize the difference between the alar and columellar walls and thus eliminate the deformity But when the nose is of normal length and the

unduly elevated ala is unilateral, the disfigurement can best be overcome by means of a V-Y shifting of flaps above the nostril (fig 368) An inverted V-shaped incision is made through the skin on the affected side of the nose, the apex toward the inner

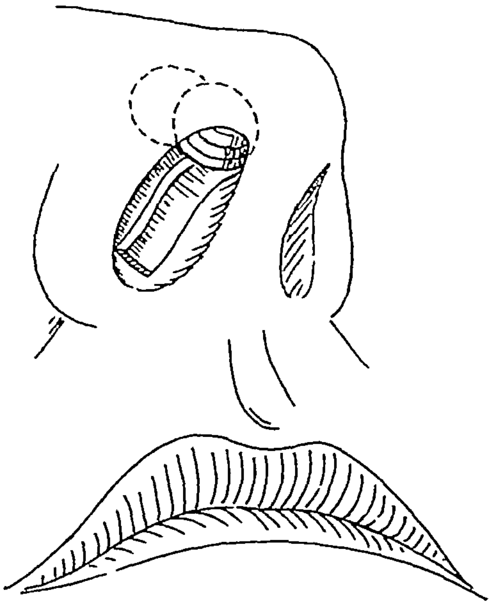


FIG 367 Walsham's operation for correction of collapsed alae Flap consisting of anterior portion of septum, 3 mm wide and 1 5 cm long and pedicled on nasal dorsum, rolled up and fastened to prepared bed beneath apex of vestibule.

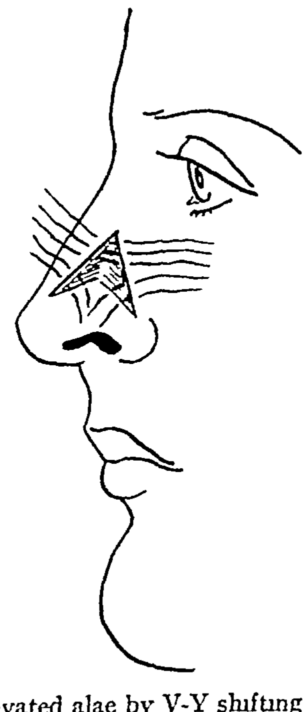


FIG 368 Correction of unduly elevated alae by V-Y shifting of flaps Inverted V-shaped incision made above affected ala Skin undermined. Ala drawn down to proper level Margins of remaining wound sutured from above downward, in form of inverted Y For details, see text (Dieffenbach)

canthus, the outer leg of the incision following the paramedian line down to a point within 1 cm of the tip, and the inner leg directed along the nasofacial groove to a point just above the outer curve of the ala The incisions are deepened to the periosteum

above and to the cartilage below, and the skin is undermined on all sides. The rim of the nostril is drawn down until it is on a level with the ala on the opposite side, and is held in position by a through-and-through mattress-suture of very fine silkworm-gut. The opposing skin margins are then approximated with fine silk, the inverted V being thus transformed into an inverted Y. The nostril is loosely packed with xeroform gauze, and a protective dressing is applied. Sutures are removed on the third or fourth day.

If there has been an appreciable loss of alar tissue and the rim is drawn upward by scar tissue, the scar is removed, and the ala brought down to its normal position. The remaining defect is covered with a contiguous flap or a graft. The details will be given later in the section on nasal deformities with loss of tissue.

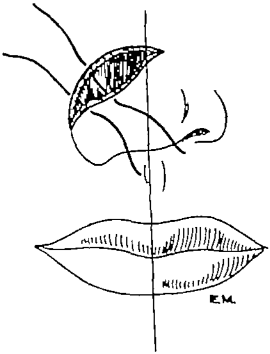


FIG. 369. Joseph operation for correction of abnormally low-positioned alae. Semilunar section excised from entire thickness of nose above alar groove. Remaining wound margins approximated.

4. *Low Position of Alae*. An abnormally low position of the alae is usually congenital and constitutes one type of "long nose." When bilateral, the deformity can be corrected by a shortening of the nose (p. 707). When unilateral, a semilunar section is excised from the entire thickness of the nose along the alar groove on the affected side. If the proper amount of tissue has been removed, the ala will be elevated to its proper position when the margins are approximated. It is important in making the excision that a little less mucous membrane be excised than skin, otherwise, the contraction of the mucosa during healing will tend to cause an eversion of the nostril (fig. 369).

5. *Abnormally Long Alae*. This disfigurement is characterized by an abnormal length of the alae in an anteroposterior direction and is associated with a prominent tip and long nostrils.

Mild forms may be corrected in the same way as a prominent tip (p. 722). But when the alae are markedly long, they are separated from the cheek along the alar

facial junctions, and from their substance triangular sections based on the margins of the nostrils are removed The reduced alae are then reattached to the cheek The remaining scars will be scarcely perceptible, as they will be hidden in the alar-facial grooves (fig 365)

6 *Irregularities of Alar Rim* The alar rim is subject to many forms of irregularity Small clefts may be corrected by slight readjustments of the adjoining skin and subcutaneous tissues, but if the tissue destruction has been considerable, the loss must be replaced The method for its accomplishment is described in the section dealing with partial rhinoplasty

7 *Abnormally Thick Alae* An abnormal thickness of the alae is due to a hypertrophy of either the soft or the cartilaginous tissues or both At times it may be so marked as to interfere with respiration If the cartilages are at fault, they are exposed

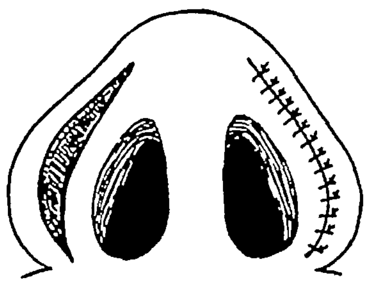


FIG 370 Reduction of thick alae Oval sections of skin and subcutaneous tissue removed Wound sutured

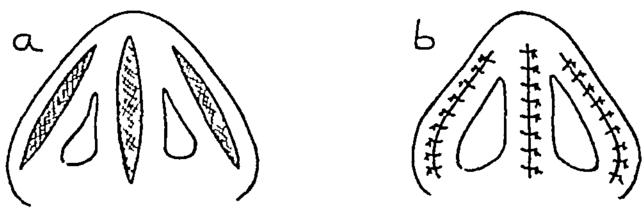


FIG 371 Reduction of thick alae and wide columella *a*, oval sections removed from alae and columella *b*, margins of wound approximated

intranasally and trimmed down to the required degree When necessary, the lateral crura may be completely removed without danger of collapse of the nostrils If both cartilage and soft tissue are hypertrophied, the alae may be thinned by the removal of oval sections of skin and subcutaneous tissue from their bases (figs 370–371) The writer prefers to operate intranasally, and thus avoid an external scar. Through the usual intranasal incision designed for the exposure of the lower lateral cartilages, the hypertrophied cartilage is laid bare and removed, together with an amount of subcutaneous soft tissue sufficient to effect the necessary narrowing In order that the reduction of the alae may be maintained, an intranasal pack is introduced, and counterpressure is applied from without It is important that the skin over the entire cartilaginous vault be mobilized, so that it may readily adjust itself to the narrowed alae

8 *Flattened Alae* Flattened alae are usually a part of cleft lip deformities, and their management is discussed in Chapter XVI

Deformities of Nostrils

The nostrils, bounded anteriorly by the lobule, laterally by the alae and columella, and posteriorly by the floor of the nose, will naturally be affected by abnormalities of any of these structures

1 *Atresia* Atresia of the *nostrils* is brought about by a destruction of the mucous membrane lining the vestibule and is usually acquired as a result of cicatricial contraction following trauma or infection, or of ulceration following syphilis rhinophyma, or lupus. In rare instances the condition is congenital, and in such cases, as a rule, it is found in combination with other deformities, such as absence of the ala on the affected side, bifid nose overdevelopment of the maxillary sinus which impinges on the nasal fossa, and cleft palate

Whatever the cause of the disfigurement, the nostrils can be restored to their normal patency only by a replacement of the lost lining by means of a skin graft. Before the operation, immobilization of the graft is provided for by the construction of a splint carrying a tray with an adjustable upright, to be attached to cap-splints on the teeth. The scar tissue within the vestibule is excised, and when the airway is completely free, a piece of modeling compound softened in hot water is placed on the tray of the splint

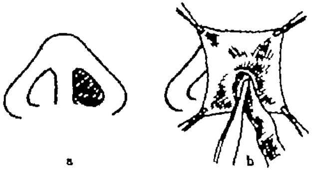


FIG. 372. Correction of atresia of nostrils *a* scar tissue removed. *b* raw area covered with skin graft held in place by gauze packing (Blair)

and introduced into the nostril and an impression of the raw area is made A thick razor graft is now cut in the usual manner (p 140), and wrapped around the mold, raw surface out. The tray bearing the graft-covered mold is inserted into the nostril and immobilized by fixing the movable upright to caps previously placed on the teeth. At the end of 10 days the mold is removed. The inner surface of the nose will be found epithelized The cavity is kept distended by means of a mold, perforated to permit of respiration until all tendency toward contraction has ceased In the absence of a specially designed splint, the graft may be held in place by means of a gauze pack (13) (fig 372) Another method of lining the raw area is depicted in Figure 373

O'Connor (229) corrects atresia in the following manner "An incision is made about the stenosed airway starting at the base of the columella, proceeding to the tip of the nose and following the natural curve of the ala. The tissue external to this incision represents the new free alar border Sharp dissection is carried into the nasal substance creating a pocket and exposing the medial crus of the ala the superior ridge of the septum the lateral crus of the ala, the lateral alar cartilage, the inferior ridge of the nasal process of the maxilla and the base of the pyriform opening of the maxilla By this dissection the distorted tip and the alar cartilages are permitted to return to their normal position, the defect is over-corrected, and a complete ring of

cartilage and bone is exposed that will act as a base for the attachment of a graft, and by its rigid ringlike structure it is possible for the grafted area to shrink only to a limited degree An impression of this subcutaneous pocket is made with Stent's composition, a dental modeling compound, and a Thiersch graft is taken, preferably from the inner surface of the arm or thigh and wrapped about the mold, which is inserted into the pocket The free edges of the skin graft overlap the new border of the columella and the ala Sutures are passed to incorporate their edges and pass over the stent impression The whole procedure so far has been accomplished outside the nasal cavity, thus eliminating infection of the graft from nasal secretions The mold is removed in from seven to ten days, at which time a complete graft of the cavity will have been accomplished The same mold or its duplicate should be sterilized and reinserted daily to continue with the necessary distention of the newly lined pocket About ten days after the epithelial pocket is made, the tissue between the old stenosed nostril and the newly grafted pocket is excised in a serrated manner, so that the medial flap of the newly epitheliated pocket can be swung into position and sutured to the remaining mucosa lining the base of the septum and the medial aspect

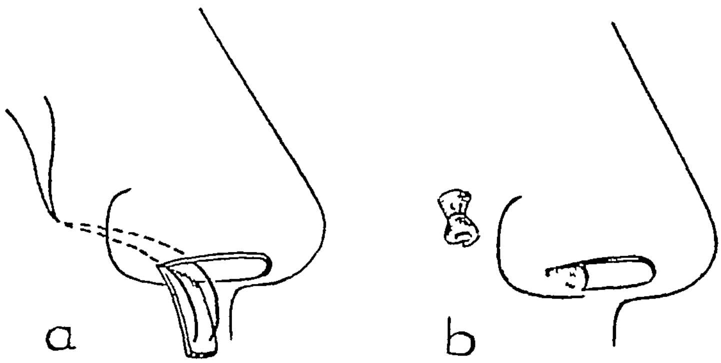


FIG 373 Correction of atresia of nostrils *a*, tissue over nares turned down in form of flap pedicled posteriorly Suture passed, to carry flap inward to line posterior nasal wall *b*, flap fixed in place Balance of raw area skin-grafted.

of the floor of the nose The serrated incision creates a series of small flaps, which are interdigitated in a star-shaped manner with the old nasal lining to obviate the formation of a ring of scar tissue at the new juncture "

Atresia of the *choanae* may be acquired as a result of hypertrophy of the turbinates, nasal polypi, tumors, inflammatory conditions, and adenoids In rare instances the condition is congenital, being due to either a membranous or a bony obstruction The condition was first described by Otto (237) (1831) Anderson states that only 150 cases of congenital choanal occlusion have been reported since 1830 and that but 6 have been observed in the section on rhinology at the Mayo Clinic since 1907 According to Stewart (296), the etiologic factors responsible for this congenital type are. "(1) Persistence of the nasobuccal membrane, (2) an overgrowth medialward of the vertical and horizontal processes of the palatal bone, and (3) results due to an inflammatory condition of the nasal passages in utero "

The symptoms of choanal atresia are inability to breathe through the affected nostril, retention of nasal secretions, and defective speech Many writers have called attention to the fact that congenital choanal occlusion is a possible unrecognized cause of infant mortality. The diagnosis may be made by gently sounding for the obstruction with

a probe passed through the nostrils or by nasopharyngoscopic and x ray examinations. The condition may also be detected by filling the nose with a colored liquid. Its failure to appear in the nasopharynx indicates atresia of the choanae (260)

If the condition is bilateral, treatment should be instituted immediately upon diagnosis but if unilateral, it may be postponed. The first operation for this affliction was reported by Emmett (1853) who broke down the occluding walls with a curved trocar The procedure was later modified by the substitution of a burr and galvanocautery for the trocar (274) Uffenorde (314) raised the mucoperiosteum of the septum as high up as the obstructing plate From the anterior surface of the latter he separated the mucoperiosteum and retracted it in the form of a flap He then removed the obstructing wall with a chisel and a curet, replaced the flap, and made a vertical incision through it. Into this incision he introduced an expanding forceps and used the redundant mucoperiosteal margins to cover the edge of the opening in the bone. Colver (32) reamed the choanae to normal size after which he introduced a piece of rubber tubing into the nostril and left it in place for a few days.

Donnelly (48) removed the obstructing plate and in order to prevent subsequent cicatricial closure of the newly made opening, skin-grafted the raw area on an obturator Under divinyl ether anesthetization the nasal mucosa was shrunk with a solution of 4 per cent cocain hydrochlorid and 1 1000 epinephrin. The choanal obstruction was perforated with a nasal Sinnexon dilator, and then a few pieces of the bony wall were removed with a small biting forceps The larger end of a Faulkner curet proved ideal for the breaking down of the remaining bony partition As a pre*caution against instrumental injury of the adjacent parts, the rotary movements of* the curet were guided by the index finger placed inside the nasopharynx. A full thickness skin graft 2 5 cm. square was fitted ' snugly around a No 18 French woven catheter which previously had been measured to equal the length of the nasal fossa from the anterior to the posterior naris. The skin graft circling the posterior end of the rubber tubing measured from 1 5 to 2 cm. in width and was attached to the catheter to prevent slipping by two No 00 catgut sutures The rubber obturator was then inserted along the floor of the nose until it reached the guiding finger in the nasopharynx. The raw surface of the graft was then in contact with the freshly denuded area of the choana. A silk suture was placed in the anterior end of the catheter, which remained immediately within the nostril, and the projecting end of the tie was anchored to the cheek by adhesive tape"

2 *Abnormally Large Nostrils* When the enlargement of the nostrils is confined to the base, the excessive width may be reduced by the excision of wedge shaped sections of skin and subcutaneous tissue from the floor of the nose on both sides of the columella, followed by approximation of the wound margins (fig 374) When the enlargement is limited to the vicinity of the apex triangular sections are removed from the under surface of the lobule on both sides of the columella. In either case care must be taken that the excised segments are of equal width and depth so that no asymmetry will result when the remaining wounds are closed. If the entire circumference of the nostrils is unduly large, these two operations may be combined and, if necessary, the alae may be reduced in length (p 735)

3 *Abnormally Small Nostrils* If the diminution in size is not due to a thickening of the alae or to an abnormal width of the columella, the nostrils may be enlarged in the following manner (fig 375) The lobule is separated from the cheek as in Weir's

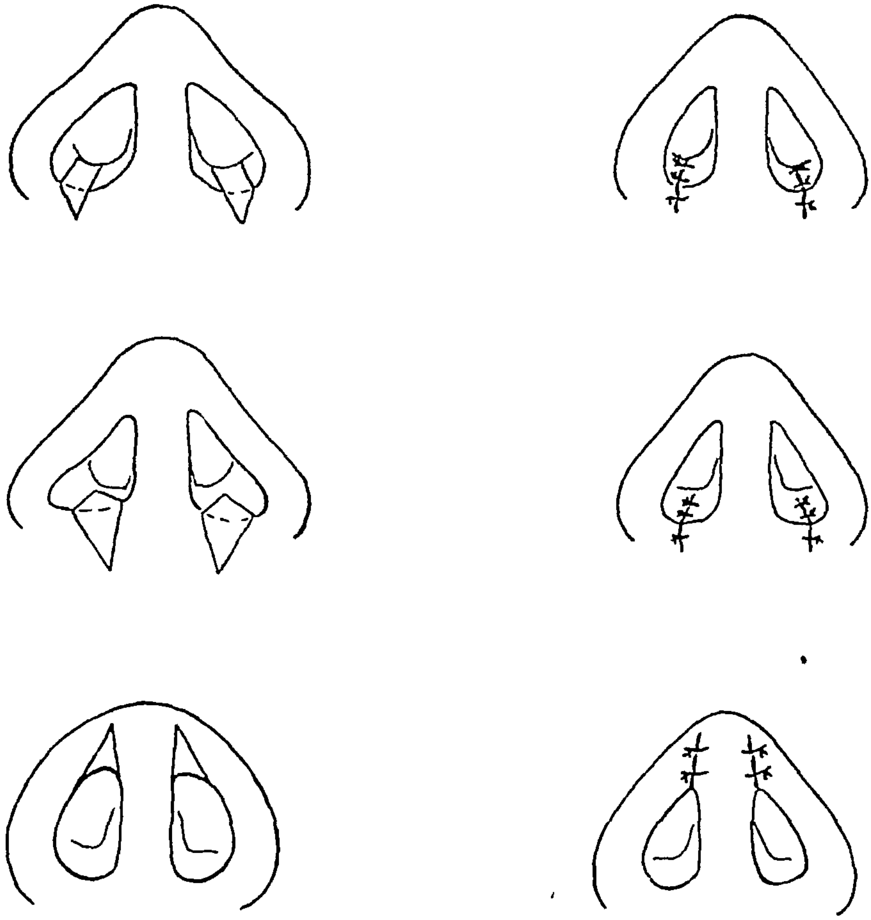


FIG 374 Reduction of abnormally large nostrils by removal of variously shaped sections of skin and subcutaneous tissue from floor of nose and apex For details, see text

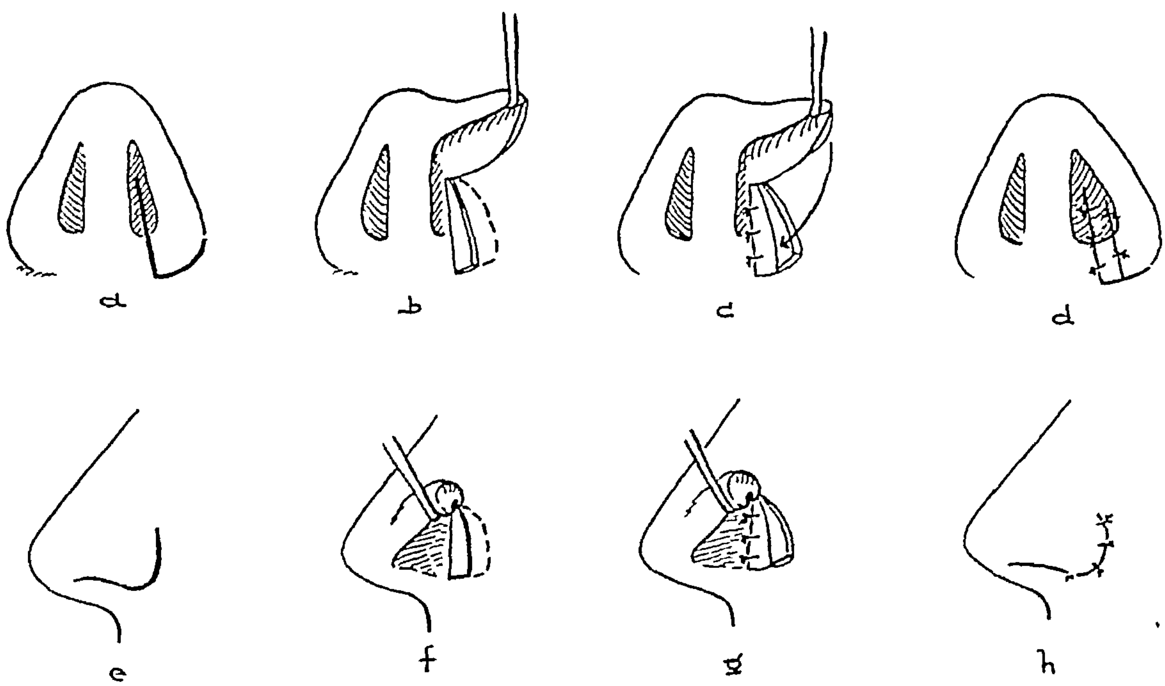


FIG 375 Enlargement of abnormally small nostrils *a*, line of incision for separation of ala from cheek *b*, ala raised Skin incision made in cheek, as indicated by dotted line *c*, flap thus outlined raised, shifted inward, and sutured in place *d*, lobule transplanted into new wound and fixed by sutures *e–h* steps of operation viewed laterally (Seiffert)

operation (p 732) A skin incision is then made parallel to the wound margin on the cheek and at a distance of 5 to 6 mm from it. The flap thus outlined is shifted medially, and the lobule is transplanted into the new wound and secured in place with sutures. The remaining scar will be inconspicuous, as it lies in a natural shadow In some cases the necessary enlargement can be obtained by means of a triangular labial flap pedicled at the base of the ala (fig 376) The secondary defect on the lip can easily be closed by direct approximation of the skin margins.

4 *Asymmetrical Nostrils* Asymmetrical nostrils most frequently result from a dislocated cartilaginous septum The lower end of the septum is dislodged from its groove in the midline of the nasal floor, and the caudal end to which the columella is attached lies across the nostril in an oblique position The lobule, deprived of its septal support, consequently droops. The deformity can be corrected by a repositioning of the septum.

FIG. 376. Correction of abnormally small nostrils by turning in triangular labial flaps pedicled at base of alae. (Joseph)

NASAL DEFORMITIES WITH LOSS OF TISSUE

TOTAL RHINOPLASTY

The early methods of rhinoplasty had little to commend them, since they were designed only for the replacement of the covering skin of the nose. Inasmuch as such reconstructions failed to provide lining and support, a nose well formed at the completion of the surgical procedure sooner or later became a shriveled mass of distorted tissue, in no way resembling the normal organ Aside from the disappointing anatomic results, the hazards of infection the secondary hemorrhage and gangrene consequent upon the absence of aseptic principles and the pain occasioned by the lack of anesthesia prevented the operation from gaining much favor It was not until the middle of the nineteenth century that the necessity of replacing lining and support as well as skin became recognized, and with the more gratifying results interest in rhinoplasty grew apace. During the World War the technic of the old Indian and Italian methods was refined, and although no new basic principles were evolved, the operation became standardized and simplified. In the post war period the continued demand consequent upon the increased mechanization of industry and the high speed transportation resulted in further technical improvements so that today patients requiring rhinoplastic operations can be reasonably assured of a nose which will harmonize with the balance of the face in size, shape projection, and color, permit of free nasal respiration, and leave a minimum of residual scarring

A passing review of the historical background of modern rhinoplasty will assist in obtaining a clear understanding of the present-day surgery In the light of modern research we may locate the birthplace of the art in Egypt and India The Ebers papyrus dating from about 1500 B C gives evidence of the fact that rhinoplastic surgery of an advanced type was practiced among the Egyptians as far back as 3500 B C Similarly, the sacred Vedas, or holy books, of equal antiquity show that the art was clearly understood by the ancient Hindus, who regarded it as a defilement and relegated its exponents to the lowest caste, the Koomas Following the course of tissue transplantation in general, the rhinoplastic operation spread from India and Egypt to southern parts of Asia, to Persia and Arabia, to Greece, to Calabria, and from there into other parts of Italy (20) Celsus (53 B C–7 A D) wrote with authority in his "De Medicina" on operations for the restoration of the nose as well as of the ears and lips Galen (130–210 A D) gave minute instructions regarding the repair of defects about the nose, ears, and mouth Throughout the Dark Ages, however, no important contributions were made to nasal surgery, the only authentic reference to the art during this period having been made by Paulus Aegineta either in the fourth, fifth, sixth, or seventh century—the exact date being under dispute—and the Indian and Italian methods of rhinoplasty were forgotten Thus Lanfranc de Milan (1295), hearing of a procedure by which a completely severed nose had been successfully replaced, remarked "This is a signal lie because the spirit which presides over life, nutrition and motion is instantly removed from the part which is separated from the body " Guy de Chauliac, the father of surgery, writing about 1360, likewise condemned the "rogues" who pretended to restore a nose that had been severed from the face

It was not until the fifteenth century that the rhinoplastic operation was resuscitated Peter Rosano, in the eighth volume of his "Annals of the World," related that in the year 1442 one Branca, a "wound doctor" from Catania, introduced the Indian method of nasal reconstruction into Europe Elysius Calentino, a Neapolitan poet of the fifteenth century, wrote to a friend who had lost his nose and adjured him to come to Naples to consult Branca Estienne Gourmelen, in his "Chirurgicae Artis Libri Tres," published in Paris in 1580, quotes from the letter "If you want a new nose pay me a visit Branca, a Sicilian surgeon, has found a way to restore lost noses He either takes flesh from the patient's arm or engrafts on his a slave's nose The thing is truly marvelous As soon as I saw it I made haste to send you the news, for to whom could it be more important? Rely upon it, if you come hither you can go away with as much nose as you like " Branca followed the ancient custom of using a flap from adjacent areas of the cheek or forehead for the repair of the nose His son, Antonius, however, in an effort to avoid further disfigurement of the face, employed skin from the arm, and to him rightly belongs credit for introducing what is known today as the Italian rhinoplastic method But credit for the use of arm flaps in nasal reconstruction is generally given to Gasparo Tagliacozzi (1546–1599), a professor of anatomy at Bologna, who was the first to write scientifically and philosophically of the method In 1597 his treatise "De Curtorum Chirurgia per Insitionem" was published (fig. 377) In this work he described several operations but gives prominence to his own special technic of rhinoplasty which has come to be known as the tagliacotian or Italian method

The following account of Tagliacozzi and his work is quoted freely from the excellent description by John Constantine Carpue (1764–1846), an English surgeon and distinguished anatomist at the Duke of York Hospital in Chelsea Gasparo Tagliacozzi was born at Bologna in the year 1546 and died in the same city at the age of fifty three For many years he occupied the chair of anatomy and medicine in the University of Bologna where he enjoyed the highest reputation, both for his general attainments

FIG 377 Second title-page of Tagliacozzi's original treatise. (See also Figure 53)

and for his operations on the ears, lips and nose. So great was his renown that after his death the magistrates of Bologna honored his memory with a statue which represented him as holding in his hands a nose, the emblem of the art which he had practised with so much fame and success. In 1597 he published in folio at Venice his book entitled "De Curtorum Chirurgia per Insitionem Libri Duo, Additis Cutis Traducis Instrumentorum Omnium atque Deligationum Iconibus et Tabulis' (305)

In the age of Tagliacozzi it was the fashion, upon every subject, to write systemati

cally, it was the fashion, also, to make a large display of reading Tagliacozzi, therefore, in treating of operations on the ears, lips, and nose, was led, by the example of his contemporaries, to say every thing which he found possible, concerning those features of the face, and to ransack, for this purpose, not only the books of medical writers, but the poets, the fathers, and even the Scriptures themselves, so, that with the help of Homer, St Augustine, Orus Apollo, Cato, Euripides, Plato, Horace, Quin-

AVTHORVM,
QVORVM IN TRACTATV
HOC FIT MENTIO, NOMINA

A

Damianus
Aetius.
Albucasis.
Alexander Benedictus.
Ambrosius Pareus
Anglorum Chronica
Apollinaris de Brachmannis
Apuleius
Argenterius
Aristoteles
Athenaeus
Auerrhoes.
D Augustinus.
Auicenna

B

Baptista Egnatius.
Biblia sacra.

C

Caelius Rhodiginus
Cardanus
Cato
Celsus.
Cicero
Columella
Cornelius Nepos.

E

Euripides

F

Fallopius.
Festus

G

Galenus.
D Gregorius.

H

Hermes Trismegistus
Hippocrates.
Homerus
Horatius.

I

Ioannes Schenckius
Iosephus Historicus
Iouius.
Iuuenalis

L

Lactantius.
Liuius
Lucretius.

O

Oribasius.
Orus Apollo.
Ouidius.

P

Palladius.
Paulus Aegineta.
Persius.
Pierius Hieroglyphicus.
Plato.
Plautus
Plutarchus.
Plinius.
Polemon.
Pomponius Gauricus.

Q

Quintilianus.

R

Rhasis.
Rufus Ephesius.
Rutilius Aemilianus

S

Stephanus Gourmelius.

T

Terentius.
Tertullianus

V

Valerius Maximus.
Valetius
Varro.
Vesalius.
Virgilius.
Vitruuius.

X

Xenophon.

INDEX

FIG 378 Index of authorities quoted in Tagliacozzi's treatise

tilian, Tertullian, Plautus, Aristotle, St Gregory, Plutarch, the book of Genesis, and many others (fig. 378), he has filled the ten first chapters, in which he examines, among similar correlative subjects, the dignity of the face, according to the poets and philosophers, the dignity of the face, according to the physicians, the dignity and composition of the lips, the dignity and construction of the ears, and the dignity and conformation of the nose

In the eleventh chapter, he arrives at a direct view of his subject, and in this and the

succeeding chapters of this book, discusses the theory of the art, and examines what ancient or more recent writers have said concerning it, and whether his own practice agrees with that spoken of by them

It is surprising how closely the conclusions of Taghacozzi and his technic compare with modern conceptions. The principle of the operation, says Tagliacozzi, in the twelfth chapter, is derived from the cultivation of trees, and, as grafts or buds are ingrafted or inoculated into stocks, so in animals, one part may be ingrafted upon another (fig 379) as, in vegetable grafting or inoculation, the stock must be cloven, or the bark perforated so must that part in the animal be wounded, upon which the extraneous part is to be ingrafted. In other respects, however, there are some differences between the animal and vegetable processes, and, among the rest, the following, that animals, being composed of parts of different conformations, the part ingrafted must agree in conformation with the part which it is to supply After these

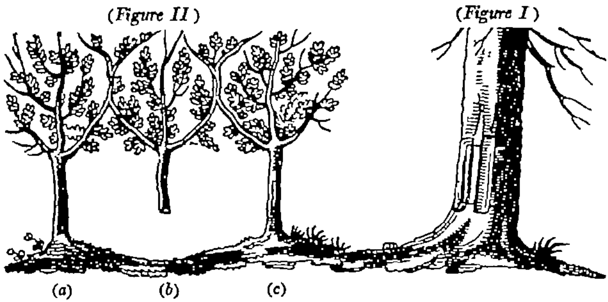


FIG 379 Reproduction of plate in Tagliacozzi's treatise, illustrating relationship of vegetable to animal grafts He states as grafts or buds are ingrafted or inoculated into stocks, so in animals, one part may be ingrafted upon another as in vegetable grafting or inoculation, the stock must be cloven or the bark perforated, so must that part in the animal be wounded, upon which the extraneous part is to be ingrafted."

observations, he proposes to consider, what material is proper to supply parts deficient, whence this material should be taken, the quantity, and the manner of agglutinating it, in other words of procuring adhesion between the one part and the other

The integuments, says he, in his thirteenth chapter, form the material from which the deficient parts must be supplied, and hence, he continues, is manifest the error of the moderns, who imagine, that noses are to be restored out of the flesh The integuments, he adds, are the material to be used, because they most resemble the material of the ears lips, and nose. It is agreed by all medical writers, that when we would supply a lost part, we must put in its place something which resembles it in substance, or if we cannot do that, something as near resemblance as we can. It is thus that we breed a callus for a broken bone, which supplies the place of true bone, and thus the first inventors of the art of restoring lost ears lips, and noses, sought their material in the integuments. He then describes four sorts of skin, with which

the different parts of the human body are covered, and determines that the skin of the arm is the best adapted to the purpose in question

In the fourteenth chapter, Tagliacozzi decides upon the place or places whence the skin should be taken, severally for the nose, lips, and ears The place, he repeats, must have a skin like the lost part, and be able to afford a sufficient quantity to supply the deficiency, and, since it must have time to unite with the defective part, it must be taken from such a part as may be brought to the other, and kept there, with as little inconvenience as possible The only part, he concludes, to supply the nose and lips, is the arm, above the elbow

The fifteenth and sixteenth chapters, contain directions on the quantity of skin to be taken, and the manner in which the parts are kept together, till natural agglutination takes place Tagliacozzi observes, that the skin, after the second cutting from the arm, sometimes shrinks an eighth, a sixth, and even a fourth part, both in length and breadth, which he accounts for by supposing, that either the nutriment is not so plentifully brought to it, as when it was united with the arm, or that the nutriment brought to it from the parts to which it is newly attached, does not assimilate with it aright He directs the surgeon to employ his discretion upon this point, and rather to take too much skin than too little The parts are to be united by means of interrupted sutures

The seventeenth chapter discusses the description of persons, as to age, constitution, and state of health, and the seasons of the year, and the time of the day, upon whom and in which the operation may be successfully performed

The eighteenth chapter is devoted to the question, whether it is preferable to take the skin from the arm of another person, or from that of the patient, whose lips or nose are to be restored It appears probable, that this chapter was written in reply to the opinions of some who held, that in theory, the arm of another person might be used

In the nineteenth chapter, he examines what ancient and later writers had said upon the subject of restoring deficiencies of the ears, lips and nose, and how far his method agrees with theirs On this occasion he refers his readers to the works of Galen, Celsus, and Paulus Aegineta, among the ancients, Alexander Benedictus, who lived after the revival of learning, and Fallopius, Vesalius, Paré and Schenk, who were his contemporaries in life, but precursors in their works Schenk he calls a most learned man of his own time

In the twentieth, twenty-first, and twenty-second chapters, he defends the operation against the charge of cruelty, which has been brought against it by calumniators, calling to the mind of his reader the various painful operations performed by surgeons in other cases In the twenty-third, he examines the differences between the several operations for the ears, lips, and nose, their respective facilities and difficulties, and, in the twenty-fourth, in what the new nose differs from the natural one, deriving those differences, in great part, from the original diversity of the skin of the arm from that of the natural nose In the twenty-fifth chapter, which concludes the book, he proposes solutions of general questions raised in what has gone before

In the second book, Tagliacozzi describes the operation After particularizing the instruments and other apparatus required, he proceeds to the delineation or marking out of the skin on the arm, which was the first thing to be performed (fig 380-(1)) A portion of integument, of sufficient size, and of a square or oblong shape, according

FIG. 380 Wood engravings from Tagliacozzi's treatise. *1* double-pedicled flap delineated on inner surface of arm. *2* skin raised, and strip of linen passed between integument and muscle. *3* proximal pedicle of flap severed. *4* apparatus for immobilization of arm to head.

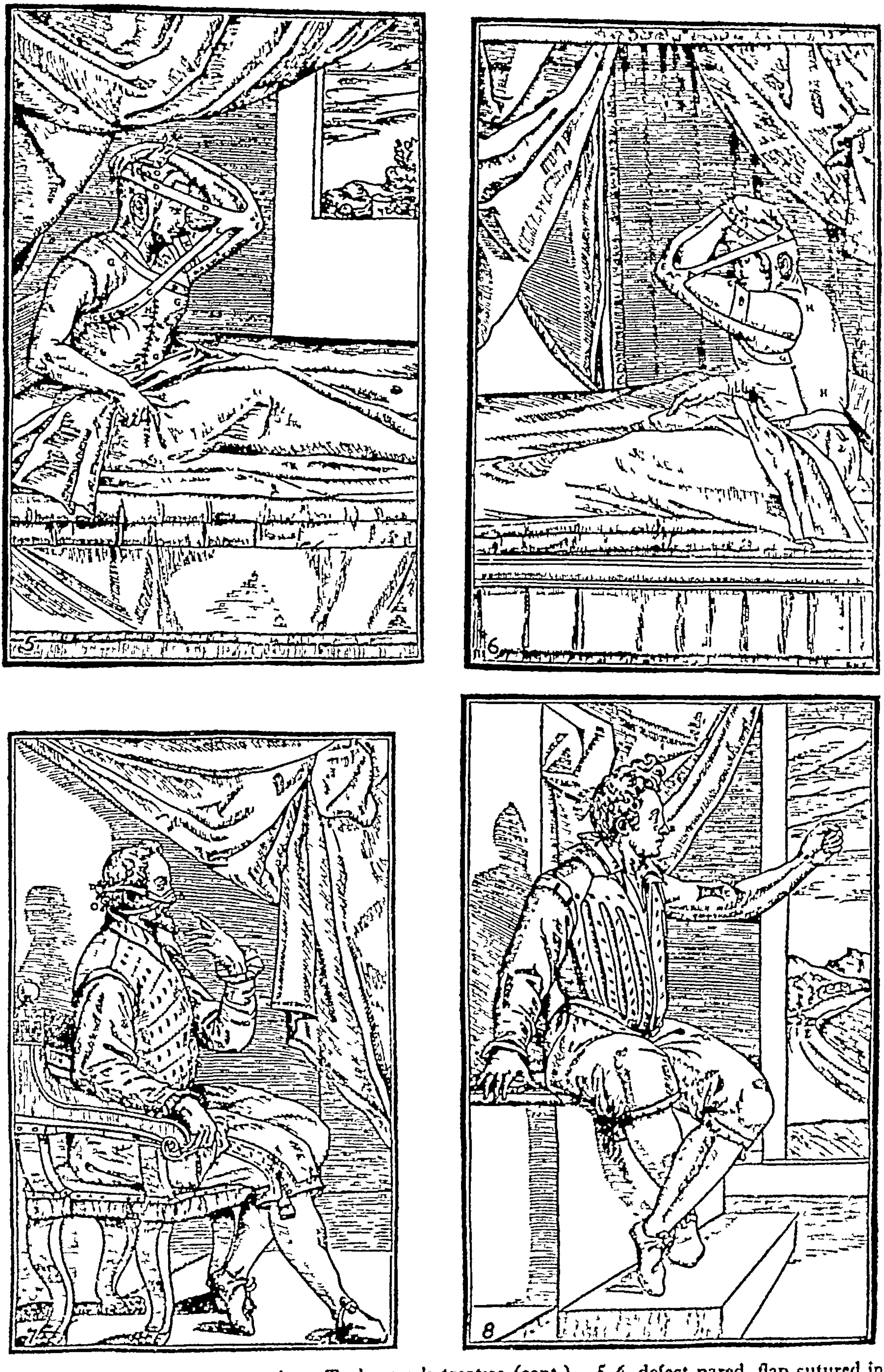


FIG 381 Wood engravings from Taghacozzi's treatise (cont.) *5–6*, defect pared, flap sutured in place, and arm immobilized to head *7–8*, donor pedicle cut, and arm released.

to the general form required, being determined on and marked, an incision was made on each side, while the upper and lower ends remained untouched This portion of integument was then dissected from the muscle beneath and a piece of linen passed between the integument and muscle (fig 380-(2)), this done, the patient was kept quiet, and the wound protected, with many precautions against inflammation and hemorrhage, for some days. Thus far, no notice was taken of the defective nose

The next stage of the operation was, to detach one of the ends of the graft, or flap of integument from the arm (fig 380-(3)) The flap when now cut at one of its ends, was turned, so that the natural surface might be outermost. If the nose or upper lip was to be supplied, then the upper end of the flap, nearest the armpit, was cut, if the lower lip, then the lower end nearest the elbow, was cut To bring the flap into contact with the lip or nose, and preserve it in that situation, without detaching it, by both its ends, from the arm, was the next thing to be done At this period of the operation, the patient put on a dress provided for the purpose (fig 380-(4)) and by means of which it was possible so to bind his arm in contact with his face so that it was no longer in his power to move the one nor the other The patient having put on the dress, the surgeon proceeded to dissect away the integuments of the edges of the deficient parts. A model of the proposed end of the nose was to be made of paper, and this, when flattened, served as a pattern for shaping the graft, or flap of skin. The flap being now brought to the nose, by lifting the arm, to which, at one end, it still adhered, and being found to fit, was fastened by ligatures (fig 381 (5), (6)) The graft, or flap of skin, having been thus applied to the defective nose, the patient was bound, so that he could not stir in any direction, and cloths dipped in a mixture of equal quantities of white of eggs and rose water were applied for an hour and a half to the wound on the arm, to prevent inflammation. Tents dipped in white of eggs were introduced into the nostrils, and pledgets, dipped in like manner, laid upon the outside.

The remainder of the second book describes the manner in which, at the end of twelve days, the patient's arm is to be released from his face, the flap being at length wholly cut away from the arm (fig 381 (7), (8)), the manner of modelling the septum, the plasters and bandages the care to be taken for some time, to defend the new nose from accidental injury and what is peculiar in the treatment of defective ears and lips. At the close of the work is a series of twenty two engravings on wood, in which are exhibited the instruments to be employed, the dress in which the patient was confined, and the various stages of the operation (fig 382)

Despite the zeal with which Tagliacozzi cultivated the art of rhinoplasty his operation died with him. Two factors contributed to this end The theologians of his time bitterly attacked him with accusations of impiously "interfering with the handiwork of God,' and attributing his success to the intervention of the 'evil one.' It is related that "a mysterious voice was heard crying "Tagliacozzi is damned," and thereupon his body was exhumed from the consecrated ground in the Church of San Giovanni Battista. The tagliacotian operation became the center around which gathered a host of legendary exaggerations told without the least regard for the actual facts. Indeed it came to be generally believed that the procedure was entirely theoretical. Thus Elroy in his Dictionnaire Historique de la Médecine printed at Mons in 1778, wrote as follows 'Many authors have spoken of Taliacotius s method, but the greater part confine themselves to mentioning it, without very much ap-

plauding it. If that physician did not himself say that he had performed the operation, his readers would be tempted to believe that his system, however ingenious, had never been found sustainable but in theory At best we do not find that he succeeded in convincing his contemporaries of the advantages of his method, for, had this been the case, experiments, made under their eyes, would have transmitted the manner of operation to the succeeding age, and, by succession, to our own, which is not without occasions for putting in practice the method of Taliacotius How many deformities would not be removed by this practice, so curious in physiology, but almost too cruel

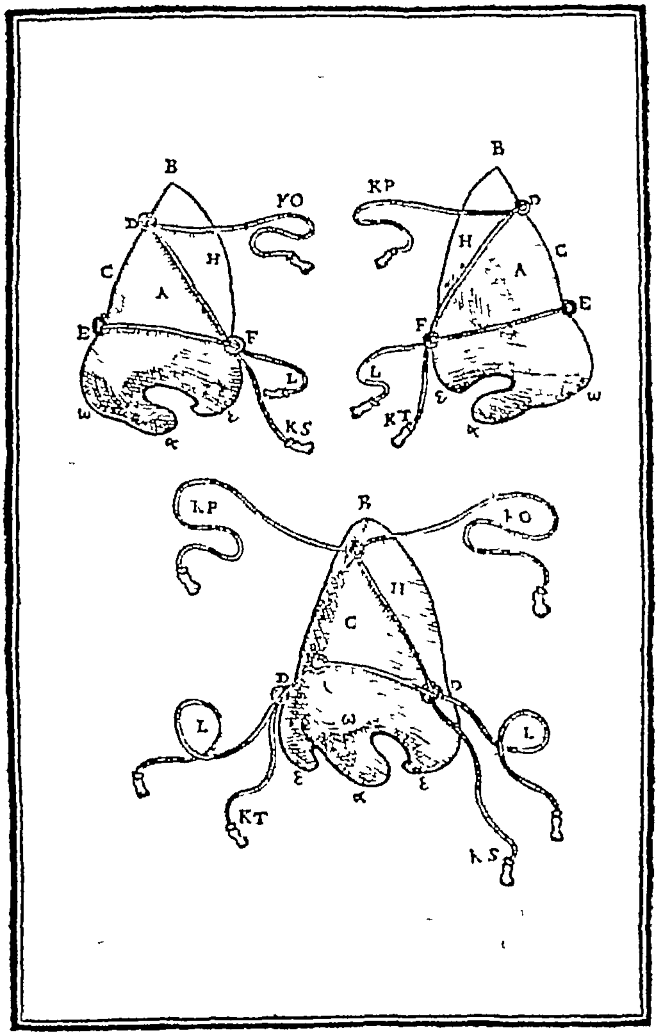


FIG 382 Wood engraving from Taghacozzi's treatise, showing type of dressing

in surgery!" Carpue asserted that it was to these superstitious exaggerations and not to the works of Taghacozzi, that Butler refers, in the first canto of Hudibras (1663):

So, learned Taliacotius, from
The brawny part of porter's bum,
Cut supplemental noses, which
Would last as long as parent-breech,
But, when the [illegible] of Nock was out,
dro[illegible] the snout.

The feasibility of the operation was again made apparent, however, when the British East India Company brought back to England reports of the Hindu method of rhinoplasty. In an article published in the Gentleman's Magazine for October, 1794, under the title "Pennant's Views of Hindoostan" there appeared a description of a rhinoplastic procedure which can reasonably be identified with that practiced in ancient India (fig. 383). The wording of the article is essentially as follows:

Cowasjee, a Mahratta, of the caste of husbandmen, was a bullock-driver with the English army, in the war of 1792, and was made prisoner by Tippoo, who cut off

Fig. 383. Illustration from article entitled "A Singular Operation" in *Gentleman's Magazine* for October, 1794. Insert figs. 1, 2 and 3, model for flap. Insert fig. 4, outline of incision for forehead flap: 2–3, to form alae; 4, to form columella; 5, pedicle of flap; 6, margins of defect, to which flap is to be attached.

his nose, and one of his hands. In this state he joined the Bombay army near Seringapatam, and is now a pensioner of the honorable East India Company. For about twelve months he was wholly without a nose, when he had a new one put on by a Mahratta surgeon at Kumar, near Poona. This operation is not uncommon in India, and has been practiced from time immemorial. Two of the medical gentlemen, Mr. Thomas Cruso, and Mr. James Findlay, of Bombay, have seen it performed as follows: A thin plate of wax is fitted to the stump of the nose, so as to make a nose

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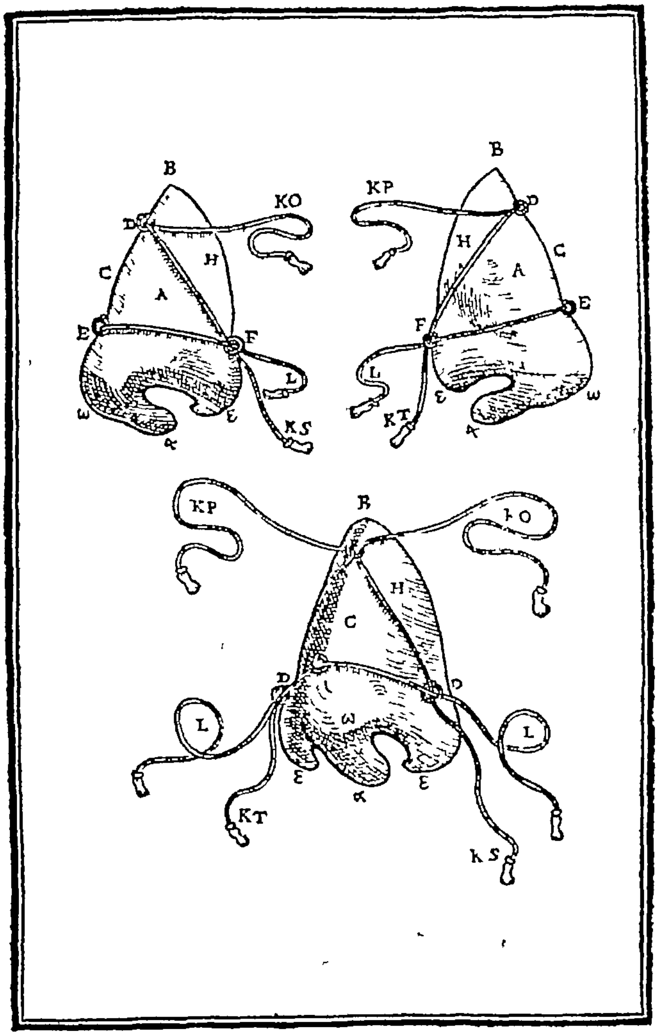

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of good appearance, it is then flattened, and laid on the forehead A line is drawn around the wax, which is then of no further use, and the operator then dissects off as much skin as it covered, leaving undivided a small slip between the eyes This slip preserves the circulation, till union has taken place between the new and old parts

AN ACCOUNT

OF

TWO SUCCESSFUL OPERATIONS

FOR

RESTORING A LOST NOSE

FROM THE

INTEGUMENTS OFTHE FOREHEAD,

IN THE CASES OF

TWO OFFICERS OF HIS MAJESTY'S ARMY

TO WHICH ARE PREFIXED,

HISTORICAL AND PHYSIOLOGICAL REMARKS

ON THE

NASAL OPERATION;

INCLUDING

DESCRIPTIONS OF THE INDIAN AND ITALIAN METHODS

BY J. C CARPUE,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS OF LONDON, AND
FORMERLY SURGEON TO THE YORK HOSPITAL, CHELSEA

WITH ENGRAVINGS, BY CHARLES TURNER,
ILLUSTRATING THE DIFFERENT STAGES OF THE CURE

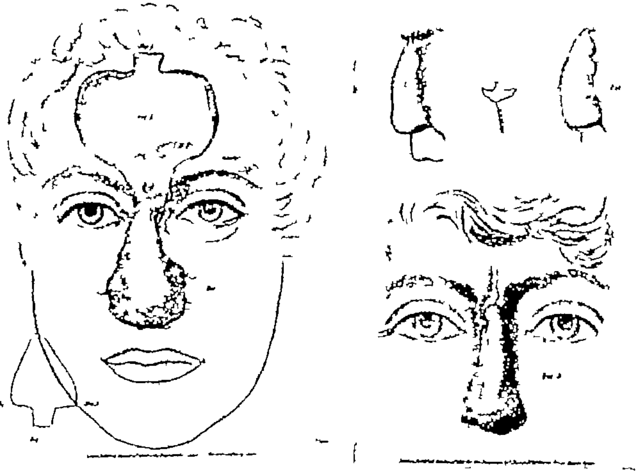
LONDON
Printed for LONGMAN, HURST, REES, ORME and BROWN, Paternoster Row, and sold by
S HIGHLEY, Fleet Street, and CALLOW, Crown Court, Soho

1816

FIG 384 Title-page of Carpue's book

The cicatrix of the stump of the nose is next pared off, and, immediately behind this raw part, an incision is made through the skin, which passes around both alae, and goes along the upper lip The skin is now brought down from the forehead, and, being twisted half round, its edge is inserted into this incision, so that a nose is formed with a double hold, above, and with its alae and septum below, fixed in the incision A

little Terra Japonica is softened with water and, being spread on slips of cloth, is dipped in ghee (a kind of butter) and applied. The connecting slip of skin is divided about the twenty fifth day when a little more dissecting is necessary to improve the appearance of the new nose. For five or six days after the operation, the patient is made to lie on his back, and on the tenth day, bits of soft cloth are put into the nostrils, to keep them sufficiently open This operation is always successful. The artificial nose is secure, and looks nearly as well as the natural one nor is the scar on the forehead very observable, after a length of time.



a b

FIG 385 Engravings from Carpue's work. *a*, forehead flap raised and rotated into defect. *b* pedicle cut. Inserts show lateral views of healed in flap

Influenced by this report, Carpue (20) became convinced of the practicability of the method and was the first English surgeon to undertake the operation (fig 384) He reported two successful cases, one in 1814 and the other in 1816 Thus, two hundred years after the death of Tagliacozzi, the rhinoplastic operation again takes its place in surgery

With reference to his first case Carpue (20) wrote 'Considering, that if my attempt succeeded I should introduce into the London practice an operation the propriety of which I had for fifteen years recommended to my pupils, I was the more anxious to have a case in which success would in all probability follow In the case presented to me, the parts had sloughed from disease the constitution had been

impaired by the liver complaint and its improper treatment I wished to determine that point, and, therefore, under pretext of preparing for the operation, I made incisions near the remains of the alae The wounds healed, and, being satisfied, now, that I had healthy part to act on, I had little doubt of complete success I relied on adhesion taking place before the cold weather set in I next, after the practice of the Indian surgeons, to whom the whole merit of the method belongs, formed a nose of wax, and commenced a series of experiments on the subject I operated in that manner eleven times" (fig 385) Due to the success of this first venture, Carpue was commanded by King George IV in the following year to undertake the case of Captain Latham who had distinguished himself on the field of battle in May, 1810

In spite of the well-nigh contemptuous regard of the leading British physicians of the day for Carpue's attempts at rhinoplasty, the success of his two operations and possibly the approbation attendant upon the royal command helped to combat the general opposition to nasal reconstruction and to restore it to its legitimate position in the field of surgery. Subsequently, the method was introduced into Germany by von Graefe (86) (1816) and Dieffenbach (44) (1829), into France by Lisfranc (178) (1826), and into the United States by Warren (324) (1837)

During the World War a special division of Maxillofacial Surgery was organized by the Medical Department of the United States Army (196), and a similar service was set up at the Queen's Hospital at Sidcup, England The activities of these organizations are too recent and too familiar to require a lengthy discussion Suffice it to say that reports of the remarkable success achieved at these centers spread rapidly, and interested students flocked there from every quarter to observe and study the work that was being accomplished They took home with them the spirit, the ideas, and the methods they had learned, and today there are clinics all over the world in which the rhinoplastic art flourishes The work of Blair, Ivy, Davis, Gillies, Joseph, Lexer, and others too numerous to mention advanced the technic rapidly. While these investigators did not originate any new basic principles, they demonstrated the advantages as well as the faults of the early methods, and for this reason they may be rightfully called the fathers of modern rhinoplastic surgery

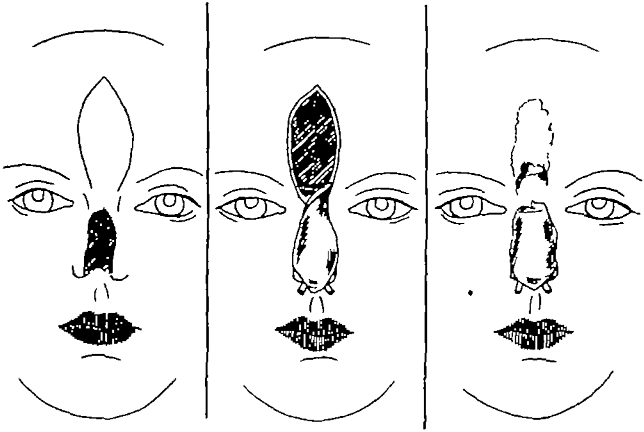
Replacement of Loss

Surgically, the nose consists of cover (skin), supporting structure (skeleton), and lining (mucous membrane), all of which, when lost, must be replaced if a successful reconstruction is to be assured

Restoration of Skin Covering

Skin covering, following a total loss of nasal structures, is supplied in the form of flaps, which may be obtained (1) from the forehead, the flap being brought into the the defect by rotation of its pedicle (Indian method), (2) from the arm or forearm, the parts being held in juxtaposition by fixation of the extremity to the head (Italian method), and (3) from immediately adjacent parts, the flap being brought into the defect by advancement of the tissues (French method) The choice will depend upon the age, physical condition, and mental state of the patient, the size of the area to be covered, the extent of scar tissue in the vicinity of the loss, and the importance attached to the resultant scars left after the raising of the flap

Indian Method The principal advantages of the forehead flap are (1) that the skin *matches the face in color and texture*, (2) *the tissues yield readily to manipulation*, and (3) the operation is less time-consuming than when flaps are taken from a distant part of the body The method is especially applicable for women, since the secondary scar on the forehead can easily be concealed by the coiffure Nevertheless, the procedure has definite drawbacks. The supply of tissue being limited, it cannot be used for the repair of additional defects about the face. In the case of men the residuary cicatrix left on the forehead is disfiguring although this objection is, as a rule, outweighed by other advantages gained If the forehead is low, the method is contra indicated, as the flap would necessarily include a portion of the hairy scalp Attempts



a b c

FIG 386 Original Indian method of rhinoplasty *a*, forehead flap outlined, with long axis parallel to long axis of face, and pedicle lying between medial extremities of eyebrow *b* flap rotated through arc of 180 degrees and sutured to pared margins of defect. *c* pedicle cut.

have been made to overcome this difficulty by x ray depilation and other expedients, but as such measures are fraught with danger and lower the viability of the flap, it is best under the circumstances to seek material elsewhere.

In the original Indian method the forehead flap was outlined with its long axis parallel to the line of the face, the pedicle lying between the medial extremities of the eyebrows (fig 386) Such a flap, however was found to have many objectionable features. It requires rotation through an arc of 180° for transference into the defect, its nutrition is inadequate and the resultant scar is conspicuous. With a view to overcoming these objections, innumerable modifications have since been made both in the position of the pedicle and in the shape and direction of the flap (fig 387) Experience has shown

that if the pedicle is directed obliquely, not only is the torsion lessened on rotation, but a shorter flap can be employed, since the pedicle itself may be used in the reconstruction of a part of the defect The shape of the free end of the flap has also been modified in an attempt to facilitate the formation of the nostrils, septum, tip of the nose, and alae The principal deviations from the original technic are listed below

Lisfranc (176) cut a vertical median forehead flap through the soft parts down to the periosteum and added a quadrilateral central extension to form the columella One limb of the pedicle was made to descend more than the other, in order to facilitate rotation Blasius (15) and Labat outlined a pear-shaped flap, the pedicle lying between the root of the nose and the inner margin of the eyebrow The free portion was divided into three sections by two incisions, the central part was tubed to form a colu-

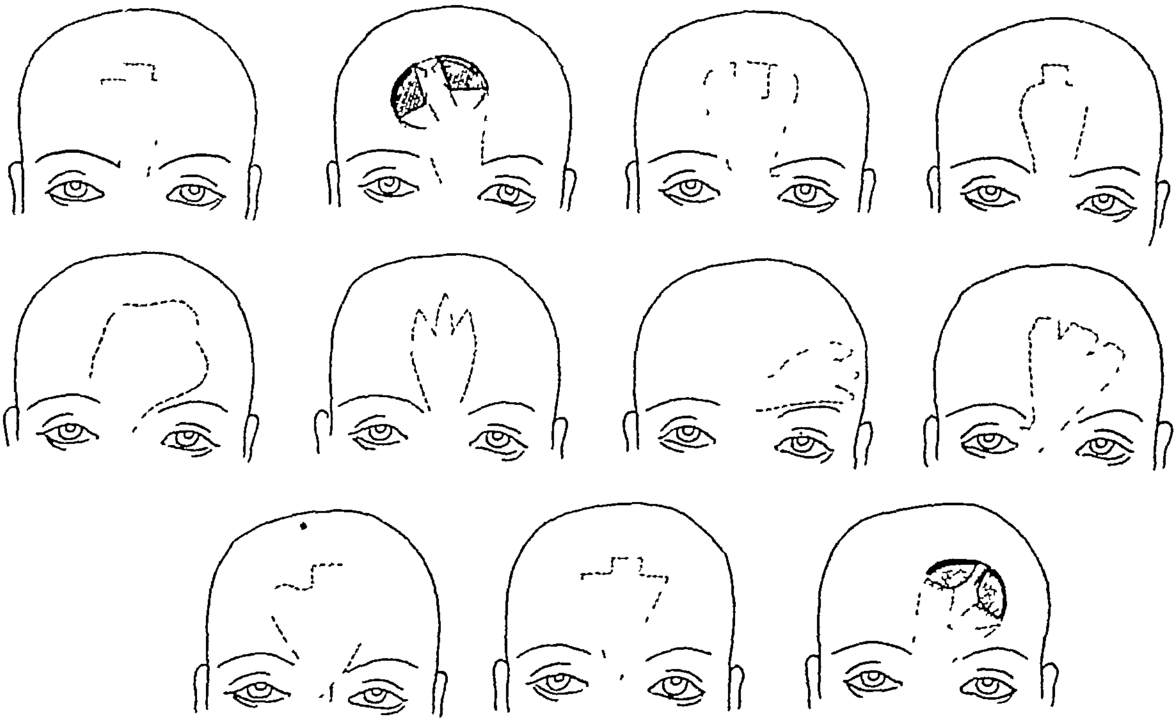
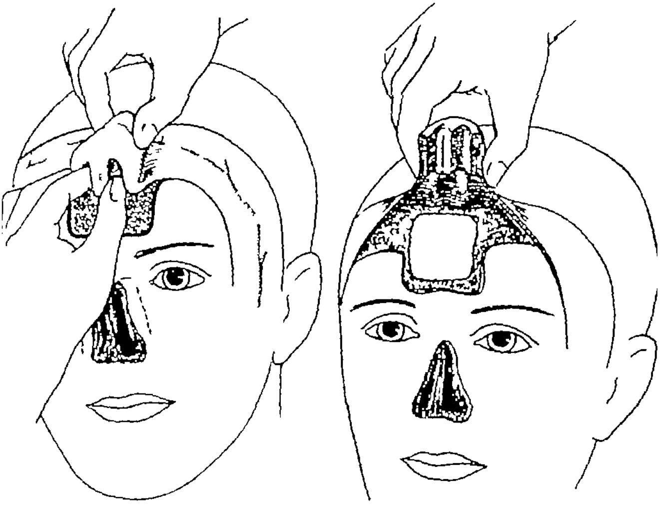


FIG 387 Modifications of original Indian method, designed to overcome its objectionable features Flap directed obliquely, to lessen torsion in rotation, pedicle employed in reconstruction, thus permitting use of shorter flap, free end of flap fashioned, to facilitate formation of lobule, columella, and alae Top row, from left to right Lisfranc, Labat and Blasius, Szymanowski, von Graefe Center row Forgue, Delpech, Landreau, von Langenbeck (third operation) Bottom row Labat, Dieffenbach, Linhart. For details, see text

mella, and the lateral portions were turned in to form the alae and lining of the nasal vestibule Szymanowski (304) prepared the flap in a manner similar to Blasius, but modified the position of the pedicle to permit of easier rotation Von Graefe (85, 86) outlined a rectangular figure at the upper border of the flap, which he employed for the formation of a columella Forgue (67) constructed an oblique cloverleaf flap, with one limb of the pedicle extending into the nasal defect Delpech (39), with a view to the formation of nostrils and columella, fashioned a flap with a trident-shaped extremity, the central segment was destined to form the columella and the lateral portions the alae Landreau (164) directed the flap transversely across the forehead, to eliminate torsion during rotation Von Langenbeck (165), in his third operation, outlined a flap which ran obliquely across the forehead To favor rotation, he carried

the left lateral incision close to the defect The skin between the pedicle and the nasal defect was removed and turned in to serve as lining, and the upper extremity of the flap was cut in such a manner as to form the columella and alae. Labat (158) outlined a vertical flap shaped like the ace of spades, and to lessen the torsion on the pedicle, he dissected a triangle of skin at the glabella and turned it down to form a part of the lining Dieffenbach's (45) method was similar to that of Lisfranc, except that the upper extremity of the flap was somewhat wider Linhart's (175) method was patterned



a b

FIG. 388. Formation of lobule columella, and alae by simple folding in of free end of flap thus over coming tendency to necrosis of narrow terminal flaps, shown in Figure 387 a, outer view of folded in flap. b inner view Raw area on forehead skin grafted

after that of Labat Blasius, but the incisions outlining the alae were more oblique, with a view to the formation of a better nostril and septum

All of the above modifications, wherein the free end of the flap is fashioned to form a columella and alae are open to the same objection—namely, that the narrowness of the flaps thus formed will impair the blood supply and lead to necrosis of the periphery Better nutrition will be obtained if the flap is cut without indentations at the free end, and the columella and alae are constructed by a simple folding in of the flap, as indicated in Figure 388

Italian Method In the Italian rhinoplasty the nasal covering is supplied by skin taken from a distant part of the body The chief advantages of the method are that

it is capable of supplying tissue in any amount and that it leaves no scars on the face. The disadvantages are that the color of the skin does not blend with its new surroundings, the subcutaneous fat interferes with modeling, and the strained position to which the patient is subjected over a period of 2 to 3 weeks causes intolerable pain

The original method of Tagliacozzi (305) was briefly as follows (figs 380–381) Two parallel skin incisions about 20 cm long were made on the inner surface of the arm over the belly of the biceps The lower pedicle of the flap was situated 3 or 4 cm above the bend of the elbow, and the upper end was directed toward the shoulder The double-pedicled flap thus formed was undermined, and, as a precaution against its readherence, a linen bandage was drawn beneath it The inevitable suppuration led in time to the formation of an undersurface of scar tissue, which in a way took the place of a lining After the circulation had become established (about 2 weeks later), the upper pedicle was cut, transferred to the pared root of the nose, and sutured in place The parts were immobilized by approximating the arm to the head by means of a specially constructed harness After the flap had healed, the remaining pedicle on the arm was severed, molded to form nostrils and columella, and sutured into the margins of the nasal defect and to the upper lip Von Graefe (86) (1817) modified the tagliacotian technic by transplanting the flap directly, and this procedure has since come to be known as the German method

Tissue from parts of the body other than the arm was also employed, being transferred to the recipient area either by migration or on an intermediate carrier Von Hacker (93) and Steinthal (295) introduced the "migration flap" incorporating chest tissues Rosenstein (259) transferred a flap from the breast to the lower part of the chin, and thence to the nasal defect Mandry (190) (1908) reconstructed a nose with skin and bone taken from the clavicle

French Method The principle of the French method of rhinoplasty is the shifting of skin flaps into the defect from adjacent parts of the face The technic originated in ancient India, was revived in Europe by Larrey (167) in 1830, and found adherents in such great surgeons as Delpech (39), Dupuytren (53), Lisfranc (177), and Serre (287). Modifications were later made by Burow (18), Hueter (113), and Nélaton (220) The sliding flap, however, because of the limited tissue available, is applicable only for the repair of small skin defects and for the replacement of lining

Restoration of Nasal Lining

As has been said before, the results of early operative procedures which aimed at the mere replacement of cover following a total loss of nasal structure were far from satisfactory Experience proved that adequate reconstruction was possible only when lining and support, as well as cover, were supplied

Restoration of the nasal lining was first attempted by Verneuil (317) (1861) who used a flap of periosteum for the purpose Volkman (321) (1866) supplied lining by turning down the skin from the upper nasal remnant, and later Keegan (138) (1900), Bardenheuer (5), and Joseph (131) constructed a lining in a similar manner (fig 389). Wood (336) (1869) formed a lining by using the skin of the upper lip, and (Hardie (97) (1875) resorted to the skin of the forefinger Thiersch (307) (1878) employed two cheek flaps turned in and hinged on the margins of the defect, and Helferich

(101, 102) (1888) raised two cheek flaps, using one for lining and the other for cover Von Kuester (153) and later Israel (119) (1894) employed an arm flap, suturing it to the defect, epithelial surface inward Koenig (150) (1896) raised two forehead

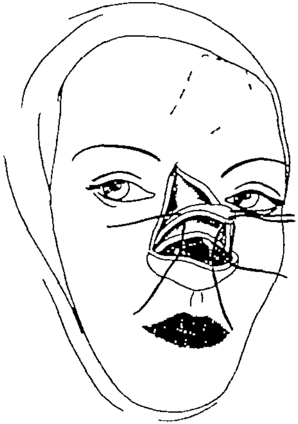
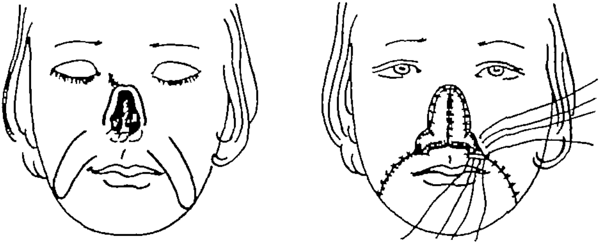


FIG 389 Restoration of nasal lining by use of skin turned down from upper nasal remnant. Dotted line shows outline of covering flap (Keegan)



a b

FIG. 390 Restoration of nasal lining by two nasolabial flaps turned up skin side in, and sutured to each other (Joseph)

flaps one of which he used for cover and the other for lining Joseph used buccolabial flaps from both cheeks. He also used flaps from the forehead and cheek, these he turned down and up respectively to cover the defect, and sutured them vertically or

roughly horizontally to each other (figs 390–391). Szymanowski (304), Dieffenbach (46), Pirogoff (247), and von Langenbeck (165) employed forehead flaps for lining An

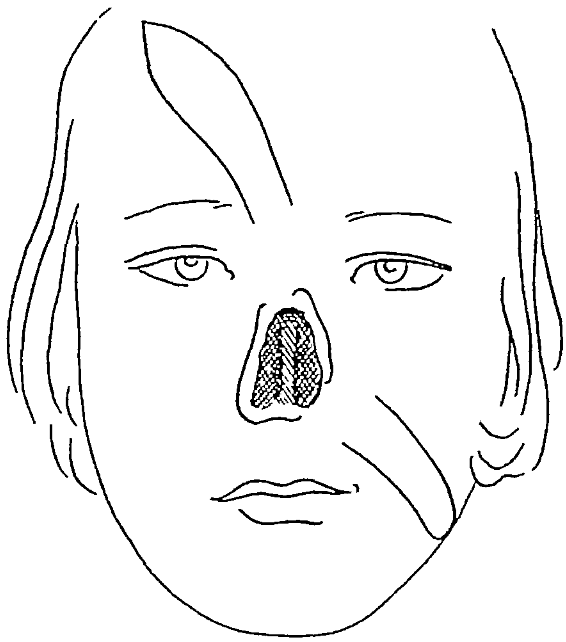


FIG 391 Restoration of nasal lining by forehead and cheek flaps turned down and up respectively and sutured to each other (Joseph)

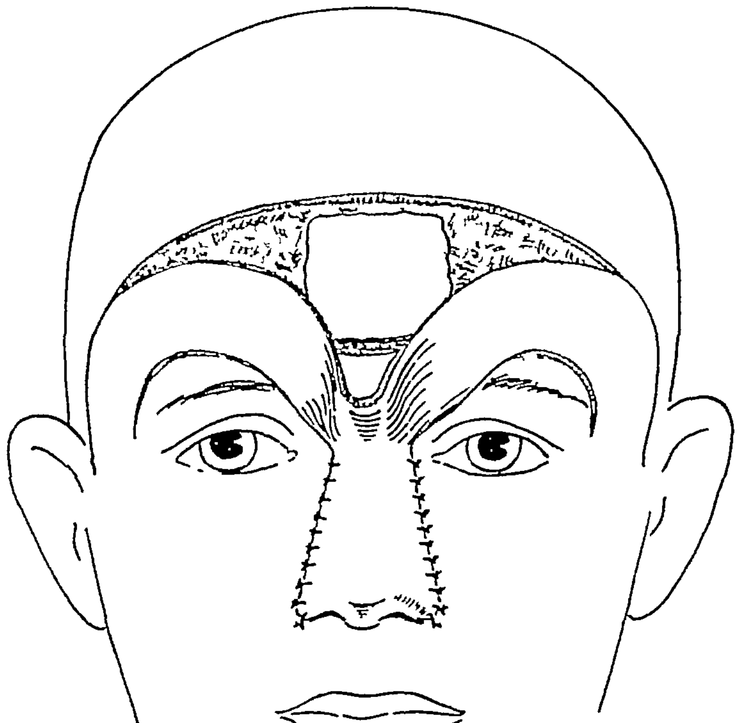


FIG 392 Restoration of nasal lining by skin-grafting Skin graft on stent mold introduced beneath covering flap prior to rotation, thus simultaneously supplying lining for flap and cover for donor site

arm flap, skin-grafted on its under surface, was advocated by Lossen (1897) for the replacement of both lining and cover Folded-over arm flaps have likewise served both purposes Skin of the breast, transferred to the defect on an arm carrier, was

utilized as lining by Burow (18), Hueter (113), Nélaton (218) and von Hacker (92) In some instances the flap was first attached to the lower part of the chin and then transferred to the defect at a later stage

Today the most practical method of providing a lining is to graft the under surface of the covering flap with a split skin or full thickness graft some time prior to its rotation into the defect (fig 392)

Restoration of Nasal Framework

Replacement of the nasal lining was a distinct advance in rhinoplastic technic, in that it safeguarded the newly constructed member against shrinkage and distortion but the nose still lacked profile projection, and to accomplish this purpose, supporting structures of all kinds have been suggested.

a b

FIG. 393 First attempt to restore nasal profile projection by skeletal support. *a*, solid lines indicate chisel-cuts *b* nasal bones rotated upward on hinge of periosteum, to support dorsum. Section from margin of pyriform opening rotated downward in like manner to support base of nose (von Langenbeck and Ollier)

Alloplastic Support

The first supportive structures suggested were of an alloplastic nature Létiévant (1879) used a metal implant. The introduction of other materials, including gutta percha, gold, silver, lead amber aluminum celluloid, hard rubber, and paraffin, soon followed. Eitner and Joseph (1915) recommended ivory Before long it was discovered that these substances were not tolerated by the tissues, being expelled in the processes of inflammation and suppuration These unfortunate results led to the use of autoplastic supporting materials of various kinds

Osteoplastic Support

1 *Support from Nasal Elements* Von Langenbeck (165) (1859) and Ollier (234) (1864) appear to have been the first to use bone as a supporting structure in nasal repair Ollier resected a fragment of bone about 1 cm wide from the margin of the pyriform opening and rotated it downward on a hinge of periosteum to furnish support for the base of the nose. He then separated the nasal bones from their attachments and swung them upward on a hinge of periosteum at the nasofrontal suture to form the dorsum

(fig 393) Despite the obvious inadequacy of the procedure, it marked the beginning of skeletal reconstruction in modern rhinoplasty

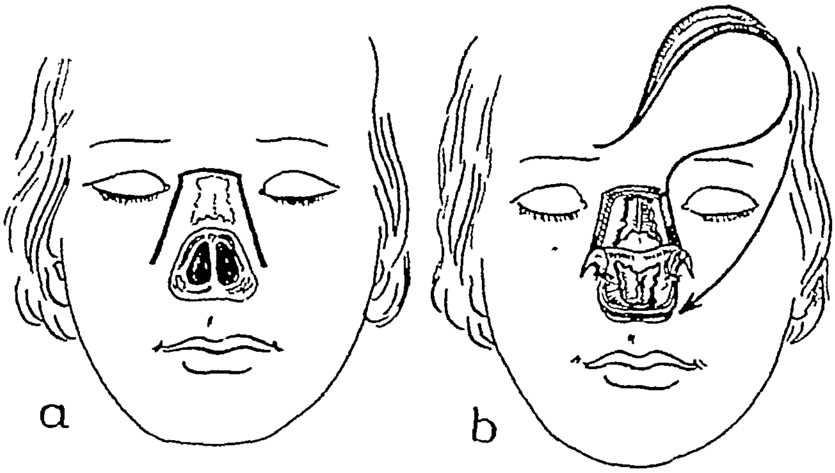


FIG 394 First attempt at simultaneous restoration of nasal support and lining, by use of remaining nasal elements *a*, inverted U-shaped flap outlined *b*, flap consisting of skin, periosteum, and nasal bones turned down Cover supplied by forehead flap (Bardenheuer) (The procedures shown in Figures 393 and 394, despite their obvious inadequacies, mark the beginning of skeletal reconstruction in modern rhinoplasty)

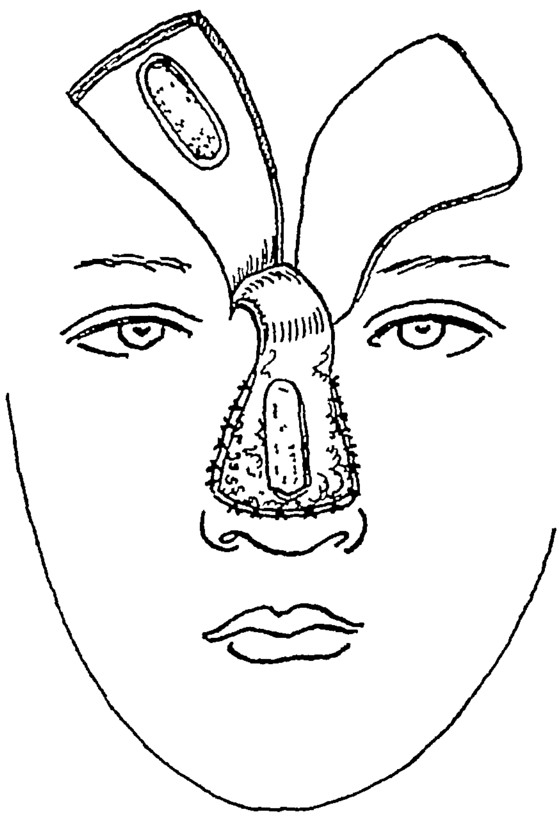


FIG 395 First attempt to obtain nasal support from frontal bone Two forehead flaps raised with pedicles at glabella One flap, containing section of outer plate of frontal bone, turned down and sutured to margins of defect, to supply lining and support Other flap, consisting of skin only, turned down for cover (Koenig) (While this method is capable of supplying adequate support, it cannot furnish the necessary nasal projection Nevertheless, it became the model for future rhinoplastic operations, in that it contemplated the restoration of lining, support, and cover)

Bardenheuer (5) (1898) supplied both lining and support by utilizing the remaining nasal elements thus (fig 394): A horizontal incision was carried across the root of the

lying below the elbow The flap, containing a section of bone 7 to 8 cm. long and 1 cm. wide, was raised and replaced. Nine days later the bone was fractured at the site of the proposed tip, bent inward, and retained in place by means of wire sutures. (b) To supply the nasal lining, a modification of Bardenheuer s (5) method was employed The remaining skin of the upper nose was outlined in the form of an inverted U and the flap thus formed was turned down to furnish the lining (c) In order that the newly formed nose might be implanted into the defect without tension, the incisions on the forearm were prolonged 10 cm. and made to diverge so that the pedicle measured about 7 cm. at its new base. The arm was raised and bent at a sharp angle, so that the dorsal surface of the hand lay over the upper part of the opposite breast, and the flap was sutured into the pared margins of the nasal defect (fig 398-b) The pedicle was severed 14 days later At the end of another 14 days secondary modeling operations were undertaken around the columella and the nostrils.

The method of Israel (118), although interesting, has many objectionable features. In the process of raising the flap the bone is likely to be separated from the overlying soft tissues and later undergo necrosis the transplanted bone does not furnish the necessary profile height, the pedicle must be made exceptionally long if the flap is to be brought into the defect without tension, and this predisposes to gangrene. Finally, the discomfort occasioned by the unnatural position of the arm during a comparatively long period is sufficient in itself to interdict the procedure

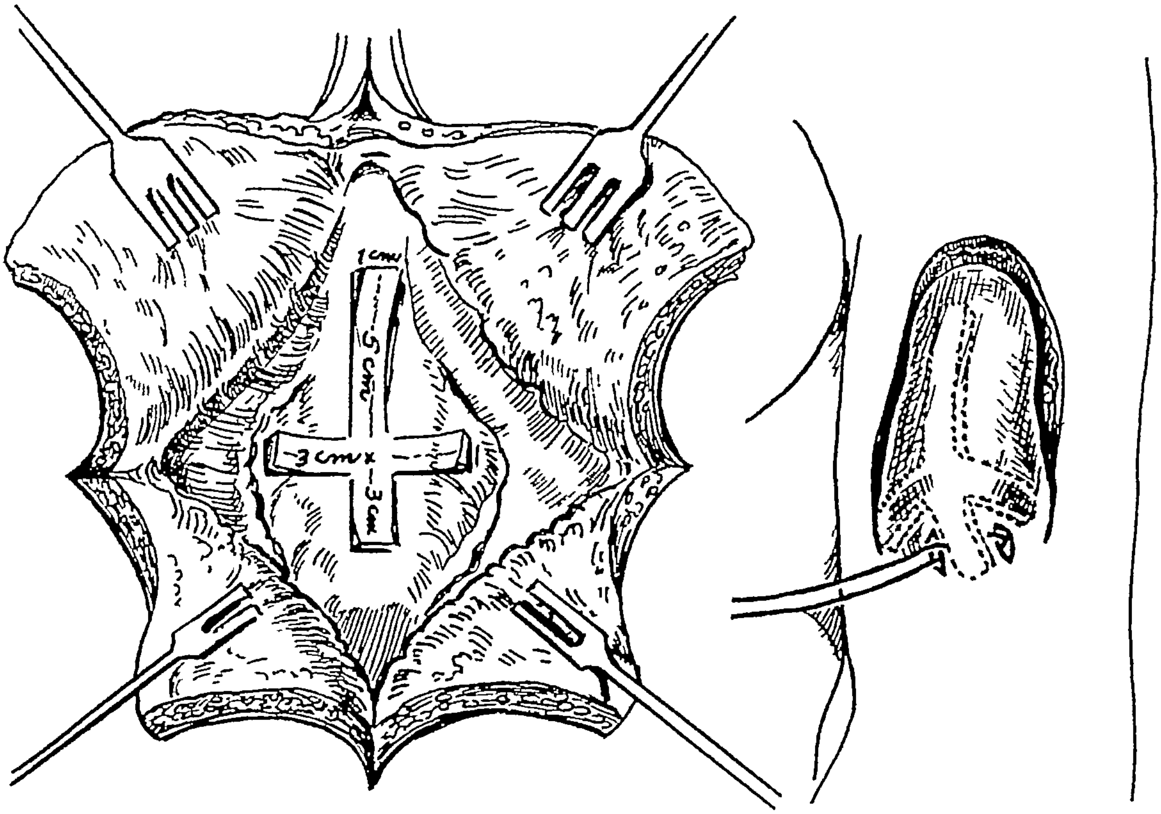
4 *Support from Tibia* Israel (118) (1896) was the first to use a tibial transplant to build up the nasal dorsum. Foramitti (66) (1907), reconstructing a syphilitic nose, implanted a piece of tibia 5 cm. long and 2.5 cm. broad under the skin of the forehead to serve as an osteal framework for the dorsum, and inserted a second strip at the base of the nose to form a support for the columella. Joseph (1914) also used two tibial grafts, the long section, destined to become the dorsum, he introduced through a glabellar incision, and the short one, intended for the columella, he inserted subcutaneously into the upper lip (p 785) Lexer (169) reconstructed the framework by using a wedge-shaped section of bone taken from the anterior edge of the tibia.

5 *Support from Clavicle and Sternum* Mandry (190) (1908) employed a portion of the clavicle for nasal support. A flap was outlined with its pedicle on the shoulder and its free end at the sternoclavicular articulation The distal end of the flap, including the required fragment of clavicle was elevated, and the skin margins were wrapped around the bone graft to serve as a lining At a later date the entire flap was raised and sutured into the pared defect.

Koenig (150) obtained supporting material from the bone of the sternum and the cartilage of the fifth rib The transplant was excised in the form of a cross implanted in the arm, and later transferred to the defect. The steps were briefly as follows (fig 399) A crucial incision was made on the chest the horizontal limb lying at the level of the fifth rib and the vertical limb passing through the midline. The 4 flaps thus outlined were raised and the muscles retracted to expose the sternum and ribs, on which a transplant was marked out in the form of an inverted cross (fig 399-a) The horizontal limb was 6 cm. long and 1 cm. wide and consisted partly of sternum and periosteum and partly of cartilage and the fifth rib and the vertical section was 8 cm long and 1 cm. wide and comprised a section of the outer plate of the sternum This cross-shaped graft was carefully dissected free from the underlying bone and cartilage in

one piece. The curving of the lateral arms toward the perichondrial surface was advantageous in that it caused the graft to conform more accurately to the shape of the nose

The graft having been procured, two parallel incisions were made on the flexor surface of the arm, the skin was undermined, and the transplant was introduced with its raw surface facing the skin The long vertical arm of the cross was directed toward the shoulder and the short one toward the bend of the elbow The transplant was held in place with a few catgut sutures The margins of the skin flap were then sutured back in place, and the graft was allowed to become established in its new bed (fig 399-b)



a b

Fig 399 Restoration of nasal support and profile projection by use of bone and cartilage graft taken from sternum *a*, sternum and adjoining costal cartilage exposed through crucial incision Cross-shaped graft, consisting of section of outer plate of sternum and costal cartilage of fifth rib, removed *b*, transplant inserted beneath arm skin After vascularization, U-shaped flap containing transplant raised, and arms of transplant bent to correspond to angle of nasal tip Skin edges folded around end destined to form columella and secured with sutures Flap later lined with thick razor graft (Koenig)

At the end of 2 or 3 weeks a flap containing the transplant and with its pedicle below was raised, and the cross was bent at the point of junction of its arms in such a way that the angle corresponded to that of the nasal tip In the skin on both sides of the limb destined to form the columella small incisions were made, and the two edges were folded around the bone and approximated The balance of the flap was then lined with a thick razor graft

After epithelization had taken place, the arm was raised and the flap brought into the defect The upper part of the bone graft was securely attached to the remaining nasal bone by means of wire sutures. The arm was supported by a plaster cast In 2 or 3 weeks the pedicle was severed and the lower part of the flap implanted in the region of the pyriform opening

The obvious objections to this method are the problem of cutting such a graft without danger of breaking it, the likelihood of necrosis, the difficulty of establishing the nasal profile height, the resultant ugly scar on the chest, and the great discomfort occasioned by the immobilization

Joseph modified the above procedure by implanting the cross-shaped bone graft after the soft parts had been replaced.

6 *Support from Phalanges* The digital method of nasal reconstruction was introduced by Hardie (97) (1875) who employed the forefinger as a supporting structure for the nose. Wolkowitsch (333) in 1896 popularized the procedure, using the fifth finger of the left hand, and this later became known as the "Russian method of rhinoplasty" Wreden (339) in 1902 implanted the ring finger in such a way that the proximal phalanx formed the columella, and the second and third phalanges the dorsum The nail and its matrix were removed from the ring finger of the left hand. The skin was stripped away to the middle phalanx, the tip of the bone being left bare. The nasal stump was pared, and the digit was introduced in such a fashion that the tip of the exposed terminal phalanx lay in contact with the nasal process of the frontal bone. The structures were held in contact with sutures and maintained in position for 2 weeks by means of a plaster cast After organization the finger was disarticulated at the metacarpophalangeal joint A week later the nasal spine of the superior maxillae was divided, and the proximal phalanx flexed, placed into the groove, and fixed by sutures, the proximal phalanx forming the columella, and the other two phalanges the dorsum. Kausch (134) in 1904 employed a toe for this purpose, transferring it on an intermediate carrier

Substitution of the nasal framework by the use of digits is unsatisfactory The nature of the tissue is unsuitable, the skin is too thin, and the circumference of a finger or toe is never equal to the two sides of the nose Furthermore the transplant has a tendency to sink or undergo necrosis leaving an unnatural and conspicuous hollow Since there are other operations which are more suitable for the purpose and can be performed without the sacrifice of a digit, this procedure has been generally discarded

Chondroplastic Support

The use of bone grafts in total rhinoplasty has been largely supplanted by that of cartilage since bone is difficult to manipulate and when transplanted into soft tissues has a tendency to undergo absorption

Von Mangold (191) (1897) was the first to employ rib cartilage in nasal reconstruction His technic was as follows A section of rib cartilage 4 to 5 cm long 1 cm wide, and about 0 5 cm thick was cut from the seventh rib cartilage on the right side. The transplant was inserted into a prepared bed through an incision in the glabella, the perichondrial surface of the graft facing the skin. At the same time, two thin cartilage strips were introduced into the alae through small incisions in the nasolabial folds. After healing had taken place, the nose was found to be too short. Lengthening was accomplished by making an inverted V shaped incision on the upper dorsum and drawing the soft parts and cartilage transplant downward The incision was sutured from above downward in the form of an inverted Y, fine silver wire being used for the purpose (fig 406)

Nélaton (216) (1902) employed costal cartilage in the form of a compound flap from the frontal region and replaced the nasal lining by turning in flaps of skin hinged on

the borders of the defect His technic was as follows. A piece of cartilage about 2.5 cm. long and 3 mm thick was cut from the rib. A notch was made in the cartilage at the point destined to form the tip of the nose The transplant was then inserted beneath the periosteum of the frontal bone Two months later a forehead flap containing the cartilage transplant was raised and rotated into the defect The embedded cartilage was bent at the previously made notch to form the columella, and its edges were folded in to form the nostrils The secondary wound in the forehead was covered with a skin graft The objection to this procedure is that the denuded surface left on the bone will not heal over until the outer plate has exfoliated

The objection to a reconstruction in which cover and support are supplied simultaneously is the difficulty of making the supporting structure occupy a median position It has been found more practical to carry out the procedure in two stages, first replacing cover and lining and then at a later date securing the necessary profile projection by the introduction of a transplant into the soft tissues

Modern Technic of Indian Rhinoplasty

Preliminary Considerations. Before any rhinoplastic measures are contemplated, a history should be obtained and a general examination undertaken, to ascertain whether the patient's physical condition warrants the operation No repair should be attempted until all signs of infection and acute active pathologic processes have been eliminated If the loss is consequent upon malignancy, a sufficient interval—preferably a year or more—must have elapsed as a guarantee against a local recurrence. The nature of the procedure, the probable number of stages, and the duration of the operation should be explained to the patient, and a choice given him between a prosthesis and a surgically reconstructed nose In the case of the aged and when there is a likelihood of recurrence of a malignancy, a prosthesis may offer the better solution Such appliances are also found convenient in many-staged operations with long intervals between The most satisfactory material for the purpose is gelatin artificially colored to match the surrounding skin (p 1389), although papier mâché, rubber, wood, porcelain, silver, celluloid, or wax are preferred by some operators If either of the latter two substances is chosen, the patient should be warned against their inflammability These appliances are held in place by the use of mastisol or by a spectacle frame attachment

The nose and the surrounding tissues are examined, to estimate the degree of destruction, so that the necessary amount of cover, lining, and support may be calculated Prior to operation the general plan of repair is worked out on a plaster cast of the disfigured face, preferably with the aid of photographs taken before the loss On the cast the defect is built up in wax or clay to approximate the size and shape of the nose to be reconstructed (fig 400) From this model the design and measurements of the proposed flap are calculated in the following manner. A piece of oiled skin or chamois skin is laid over the built-up nose on the cast The upper end is held against the glabella, and the lower portion is folded in to form a columella and a lining for the vestibule The pattern is cut around in such a manner that sufficient material will be left to cover the nose amply without tension When the material is unfolded, it will be found to be more or less pear-shaped From this a second pattern is constructed in tin or lead, of the same shape but about a third larger, to allow for shrinkage and possible failure of marginal union While it is difficult to foretell the exact amount

of shrinkage that will take place, since it varies in each instance, as a rule, if the flap is well lined, the contraction will not exceed this amount. The metal pattern has the advantage of retaining the form into which it is molded and can be sterilized together with the instruments. For recording purposes the patient s name and the date should be marked on the pattern

Several days before the contemplated operation the exposed nasal mucosa is cleansed, all crusts are removed, and the nose and pharynx are sprayed at 3- or 4-hour intervals with an oily antiseptic. The operation may be performed under local or general anesthesia. If the latter is used the endotracheal method of induction is preferable as the pharynx can be packed off and the anesthetist be away from the operative field The preparation and draping are carried out in the customary manner (p 669) Throughout the operation rigid asepsis must be adhered to since infection will invalidate the most skillfully executed reconstruction.

Operative Steps. Assuming that the flap is to be taken from the forehead, the operative steps in a typical rhinoplasty are carried out in the following order (fig 401)

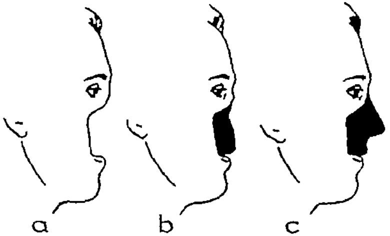


Fig. 400. Preoperative planning of nasal repair on plaster cast. *a* defect. *b–c* defect built out in wax to approximate size and shape of nose to be constructed. From this model, design and measurements of proposed flap are calculated. For details, see text.

1 *Restoration of Airways and Preparation of Foundation.* The scar tissue over the stenosed nasal apertures and along the edges of the defect is removed. The mucosa and skin along the wound margin are split into two layers, to facilitate the attachment of the flap If a part of the septum is intact, the mucoperichondrium is separated on both sides, to provide for union with the proposed columella Any usable excess tissue around the tip or alae is turned in and made to serve as part of the lining The airway is cleared by excising all scar tissue as far as the pyriform opening Should the aperture be narrowed, it is enlarged by chiseling off its margins. If the nasal bones project to such a degree that the support which is to be inserted later would make the bridge too high, the excess is pared at this time. Occasionally, the entire foundation of the nose suffers destruction, and under such circumstances a new base must be created. This can usually be accomplished by rotating two nasolabial flaps, skin side in and suturing them to the remaining nasal mucosa.

2 *Restoration of Lining* The lining may be supplied in many ways If there is a sufficient amount of unscarred, well nourished tissue adjacent to the defect, contiguous flaps pedicled on the margins of the defect may be rotated through an arc of

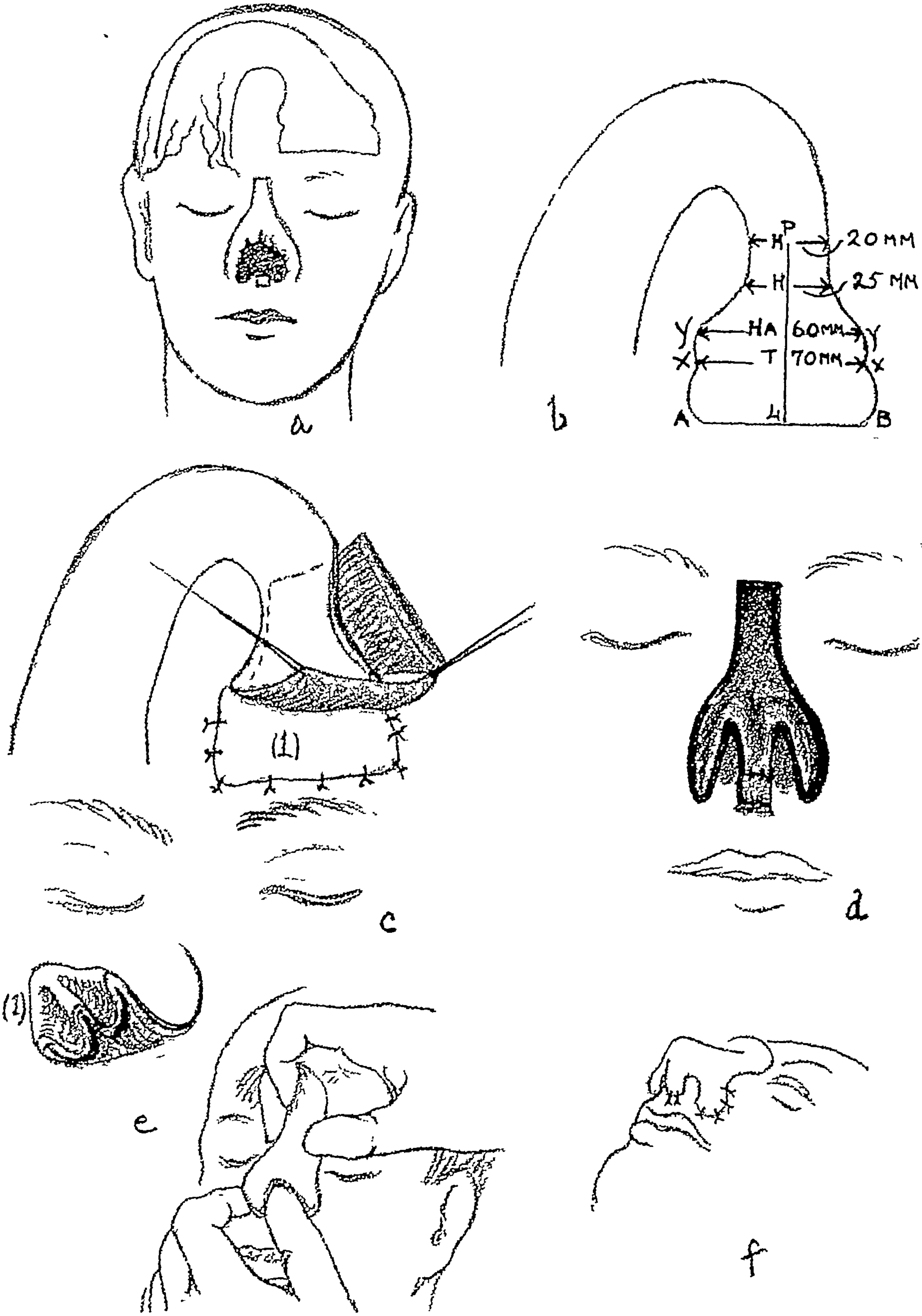


FIG 401 Technic of total rhinoplasty *a*, outline of nasal remnant to be turned skin side in, to form lining (Bardenheuer) Forehead flap outlined, containing angular, frontal, and anterior temporal arteries in pedicle (Kilner) *b*, dimensions of covering flap *A–B*, width at alae, *P–L*, nasal dorsum, *L*, point of union of columella with lip Distance from tip of nose to nasion measured and marked on line *P–L* (Smith) *c*, flap raised and sutured back in place. At another stage, under surface of upper part of flap skin-grafted on stent mold *1*, secondary forehead defect skin-grafted (New and Figi) *d*, skin along margins of defect turned in, to form lining *e*, forehead flap rotated into defect, and distal end pinched in, to form nostrils and columella Insert *1* shows under surface of folded-in flap *f*, flap sutured in place For details, see text

180° and sutured together in the midline. Or, the nasal skin may be turned down over the defect in the form of an inverted U-shaped flap, as suggested by Bardenheuer (p 758) Unfortunately, in the majority of patients requiring rhinoplastic operations the skin surrounding the defect is scarred and of such poor quality that rotation through so wide an arc is likely to lead to necrosis In such cases the lining may be replaced either by skin-grafting the under surface of the covering flap prior to its transfer, or by covering the defect with two skin flaps taken from the labiofacial folds and with their pedicles just below the alae, according to the methods of Thiersch (307) and von Hacker (92) (fig 390)

3 *Restoration of Cover* The pattern previously made from the built up cast is placed on the forehead in such a manner that the pedicle when rotated will be under a minimum of tension In order that the flap may be amply nourished, the pedicle should be as wide as the flap itself and so situated as to include either the angular, nasal, frontal, or anterior temporal artery It is usually made to lie over the glabella, but if the skin in this region is scarred, it may be formed in the temporal region, the flap being directed obliquely across the forehead. The free end of the flap is carried straight up or to one side, depending upon the length of the forehead and the size of the defect to be covered. In any case it should be sufficiently large to furnish both a columella and a lining for the vestibule.

When the most suitable position for the flap has been decided upon it is outlined and raised, care being taken to avoid traumatization of its margins. At the pedicle the plane of separation should be just above the pericranium, but the distal portion destined to line the nostrils and form the columella, should be elevated in the plane above the epicranius muscle, so that the tissues will not be too bulky While the flap is being raised hemorrhage is controlled by pressure over the eyebrows and temporal region. After its complete separation the individual blood vessels are caught with fine-pointed hemostats and tied. If the patient is advanced in years or if there is reason to suspect defective nutrition the flap is dissected free, except at its upper and lower ends and then sutured back in its original bed for a week or 10 days before being rotated into the defect

In case provision has not yet been made for a lining a split-skin graft wrapped around a stent mold is inserted beneath the forehead flap The flap is then sutured back into place and not disturbed for 10 days. At the end of this time the flap is raised and the stent removed. Both the under surface of the flap and the secondary defect on the forehead will be found covered with epithelium.

When the flap is ready for implantation, it is rotated into the defect, its distal end is pinched in to form the columella and alae, and it is carefully sutured in place The suturing is begun by attaching the columella to the philtrum, and is continued laterally around the alar bases and upward along the junction of the cheek and flap, interrupted sutures of horsehair being used. A dressing is then applied, care being taken to avoid compression of the pedicle The sutures are removed on the sixth day

Three or 4 weeks later the pedicle is divided, and the stump is returned to the forehead. Kilner (144) warns against leaving too little skin in the flap "It is wiser to leave too much to be trimmed to suit the defect, which is clearly visible only after division of the pedicle than to return to the forehead even a small area of skin which one has planned so carefully to leave behind in the new nose"

At the end of 3 weeks, and after the nose has been rendered soft and pliable by massage, the necessary profile projection is provided by the insertion into a previously prepared bed of an angulated transplant through a central columellar incision, as described on page 701 If the secondary defect on the forehead was not covered at the time that the flap was rotated, the granulations are now cleanly excised, and the area is covered with a split-skin graft (p 140)

New and Figi (227) raise the forehead flap and provide a lining as follows "The flap is outlined on the forehead with indelible pencil according to the prepared pattern, the most advantageous situation and the direction of its axis having been previously determined The pedicle is placed just over the glabella or the root of the nose and the inner portion of the brow of the side opposite the defect, provided this is unilateral, unless the scarring on the forehead can be better concealed by running it in the counter direction Clean-cut incisions are carried through the skin and subcutaneous tissues and frequently through the frontalis muscle as well, the thicker the flap the better will be its blood supply At the first elevation, an attachment is left at the upper or distal end of the flap to safeguard the vitality of this portion The bleeding having been carefully controlled, a full thickness skin graft taken from the inner aspect of the upper arm is inserted beneath the distal end, with its raw surface in contact with the under surface of the flap This is cut to an exact pattern corresponding with this part of the flap and serves as a lining for the reconstructed wall of the nose Frequently at the same time a second Wolfe graft is placed beneath the first in order to supply a covering of skin for the portion of the forehead now overlain by the part of the flap to be used in the reconstruction These grafts are held in place by transfixing them with the sutures closing the wound on the forehead A firm pressure dressing is applied subsequently and maintained for 10 days" (fig 401-c)

Secondary Modeling At this stage of the procedure the nose has the appearance of a more or less shapeless mass, resembling a potato on the face It is as a rule excessively broad and thick, with asymmetrical alae and unduly narrow nostrils Before the reconstruction can be considered satisfactory, these disfigurements must be corrected by subcutaneous excisions, rearrangement of flaps, transplantation of tissues, etc , the choice of procedure depending upon the nature of the defect These measures, however, cannot be carried out to advantage until the tissues have completely healed in

1 *Frontonasal Angle* The frontonasal angle is re-established by removing the scar tissue and thickened subcutaneous tissue over the root of the nose and carefully approximating the skin edges (fig 402)

2 *Lobule* The tip of the nose rarely needs readjustment, since its shape and support are usually provided for when the framework is planned But should it appear too flat and lack sufficient projection, a modeled piece of cartilage or bone transplanted subcutaneously will give it the desired contour The technic is as follows (fig 404) A semilunar incision, convex posteriorly, is made below the tip, just above the apices of the nostrils, and through this incision a bean-shaped section of costal cartilage is introduced subcutaneously and forced upward until it rests on top of the dorsal graft The small graft is immobilized for a few days by means of peg-pins pushed through the skin The semilunar incision is allowed to heal by granulation, so that the contraction of the resultant scar will cause a gradual rounding off of the tip (169)

3 *Alae* Before the nose can assume natural appearance, the normal alar grooves

must be reproduced An arched incision is made in the skin along the line of the proposed groove, and after enough subcutaneous fat has been removed to bring about the desired depression, a comma shaped section of skin is excised, as shown in Figure 403 and the wound edges are carefully approximated. When cicatrization has taken place, the depressed scar will duplicate the alar groove.

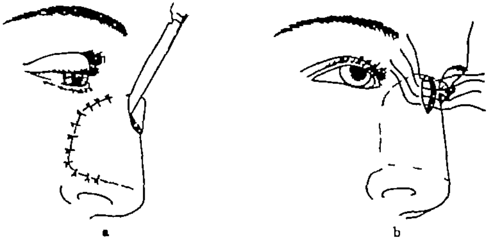


FIG 402. Secondary modeling following rhinoplastic operation. Establishment of frontonasal angle. *a*, scar and thickened subcutaneous tissue removed from root of nose. *b* wound margins approximated. (Joseph)

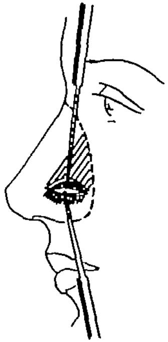


FIG. 403 Secondary modeling following rhinoplastic operation. Formation of alar groove. Arched incision made along line of proposed alar groove. Tissues excised subcutaneously as indicated by shaded areas. Comma-shaped section of skin removed along line of alar groove Skin margins approximated. (Joseph)

As a result of uneven cicatrization the alae may become asymmetrical and require repositioning To effect this the affected ala is separated from the cheek by means of a curved incision and replaced on a line with its fellow Subcutaneous excisions may likewise be necessary to equalize the thickness on both sides (fig 405)

4 *Dorsum.* If after the reconstruction the bone or cartilage transplant is found

to be out of alinement, it can be mobilized and readjusted through the original incision and held in the corrected position by means of a stent dressing (fig 261)

Should the dorsal transplant fail to give the proper profile height, another piece of bone or cartilage of the required size and shape may be inserted subcutaneously through the opening provided by the excision of the original glabellar scar

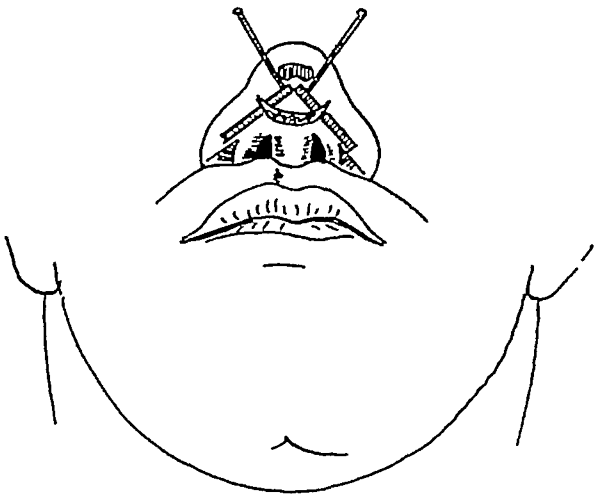
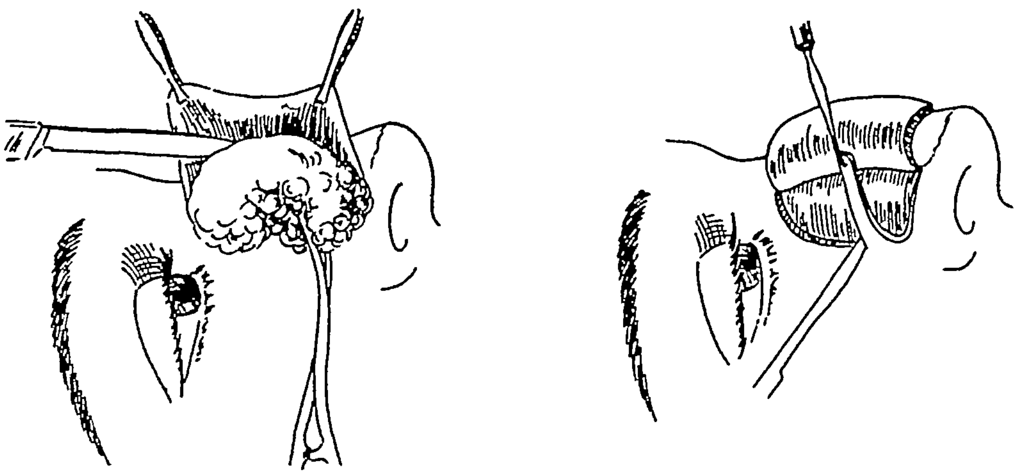


FIG 404 Secondary modeling following rhinoplastic operation Raising of nasal tip Modeled piece of cartilage or bone introduced through semilunar incision made below tip, and forced upward to rest on top of dorsal support Graft immobilized by peg-pins Semilunar incision allowed to heal by granulation, so that contraction of scar will round out tip (Lexer)



a b

FIG 405 Secondary modeling following rhinoplastic operation Reduction of undue thickness and removal of lateral scar *a*, original scar incised Flap raised, and excess subcutaneous fat removed *b*, scarred margin excised, and flap sutured back in place

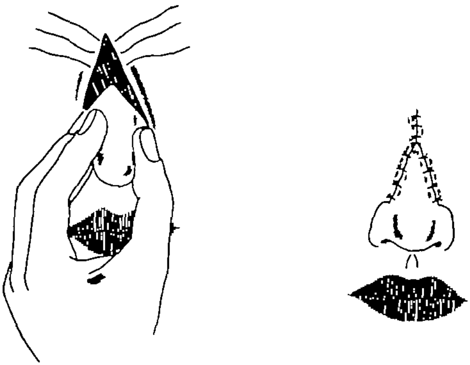
If the reconstructed nose is abnormally short, it can be lengthened by V-Y advancement (fig 406)

5 *Nostrils.* If the airways are too small to permit of easy respiration, the tissues of the vestibule between the nares and the pyriform opening are excised, and the raw area is skin-grafted A mold of the raw area is made in softened stent, covered with a thick razor graft, raw surface out, introduced into the nostril, and secured in position for 10 days In place of modeling compound Esser (59) uses two corks of an appropriate shape and size Joseph (133) advocated the use of drainage tubes, on the grounds that

they provided for nasal breathing while epithelization was taking place. In any case, as a precaution against ultimate stenosis, nasal tubes should be worn for several weeks after the graft has healed in place.

Figure 407 shows the results of a reconstruction following an extensive loss of nasal and cheek tissue.

Complications. Under normal conditions the inflammatory reaction following the reconstruction begins to subside about the third or fourth day Should suppuration follow the introduction of a bone graft, it is advisable to remove the transplant immediately and institute drainage. In the case of a cartilage graft, however, a more expectant attitude is justified, since cartilage is better able to withstand the suppurative process than bone. If the transplant perforates the skin, as a result of its having been



a b

FIG 406. Secondary modeling following rhinoplastic operation. Lengthening of reconstructed nose by V Y advancement. *a* inverted V-shaped incision made, and nose brought down. *b* wound sutured in form of inverted Y

implanted under too great tension, it should be extracted and implanted under the skin of the abdomen After the wound on the nose has completely healed, the graft is removed from its temporary bed remodeled and replaced without tension into its ultimate site. Should the formation of a sinus give evidence of the fact that the transplant has undergone necrosis, the graft should be removed at once. If the sinus has opened externally, healing will result in a depressed scar above the dorsum and secondary correction will be necessary

Lexer's Indian Method. Lexer's Indian method is a modification of the original procedures of Schimmelbusch and Koenig The technic is as follows (fig 408)

1 *Preparation of Defect* The air passages are established in the customary manner (p 771) The raw surfaces on the inner aspects of the nostrils left after the removal of the scar tissue are covered with two narrow skin flaps raised from the margins of the

apertures, one with its pedicle above and the other with its pedicle below (fig 408-a) These small flaps are rotated inward and anchored in place with pegs driven through

FIG 407 Reconstruction following extensive destruction of nose and left maxilla, with downward slump of left lip, cheek, palpebral fissure, and eyeball *A*, frontal view *B*, profile view *C*, early splinting *D*, clay nose built up on plaster model, used as pattern for reconstruction *E*, tinfoil pattern of flap *F*, forehead flap turned down *G*, costal cartilage graft inserted *H–I*, profile view of reconstruction (Medical Dept, U S Army, Vol XI)

the flap into the bone (fig 408-b) Any remaining small denuded areas are covered by means of thin razor grafts wrapped around stent molds.

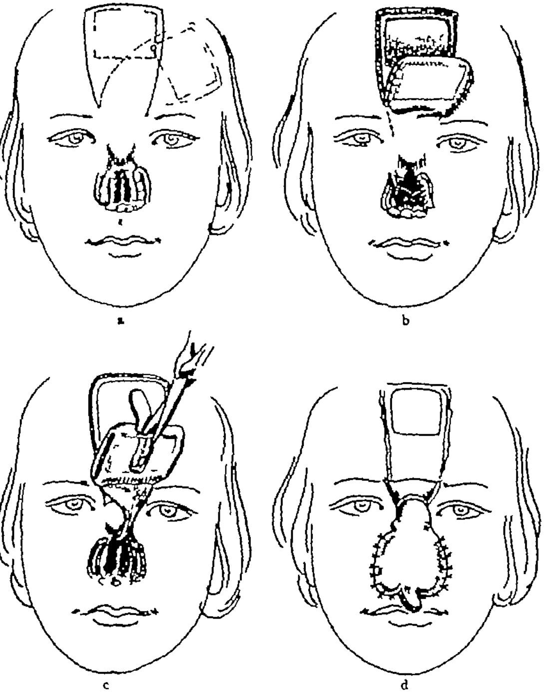


Fig 408 Lexer's Indian rhinoplasty *a* airways prepared by removal of scar tissue. Narrow skin flaps outlined on margins of nasal apertures, one with pedicle above and other below Forehead flap, including section of outer plate of frontal bone, outlined (Dotted line indicates alternative position of flap.) *b* marginal flaps rotated inward and anchored with peg-pins driven into bone. Terminal end of forehead flap raised and turned in, to enclose bone. Lateral margins of flap sutured Secondary forehead defect covered with full thickness skin graft Three or 4 weeks later pedicle lengthened. Incision carried into defect on one side, but only to inner canthus on other to preserve angular artery *c* one week later tongue-shaped section of skin cut from under surface of forehead flap, to serve as columella. Bone thus bared divided longitudinally with scissors *d* flap bent in form of gable, rotated downward, and sutured to freshened margins of periosteum around pyriform opening and to denuded skin margins Secondary modeling carried out at later stage

2 *Forehead Flap* A flap with a broad pedicle situated between the eyebrows is outlined and raised including a section of the outer plate of the frontal bone 2 cm. wide

and 8 to 10 cm long (fig 408-a). The terminal end of the flap is folded over, so that the bone is sandwiched in between two layers of skin, and the lateral margins of the flap are sutured together (fig. 408-b) The secondary defect on the forehead is covered with a full thickness skin graft

3 *Lengthening of Pedicle* Three or 4 weeks later the pedicle is gradually lengthened (fig 408-b) On one side the incision is carried into the defect, but on the other it is prolonged only to the inner canthus, so that the angular artery from which the flap derives its nutrition may be preserved

4. *Formation of Columella and Dorsum* A week later a tongue-shaped section of skin is cut from the under surface of the forehead flap to serve as columella (fig. 408-c) The bone thus bared is divided longitudinally either with a saw or a pair of bone scissors

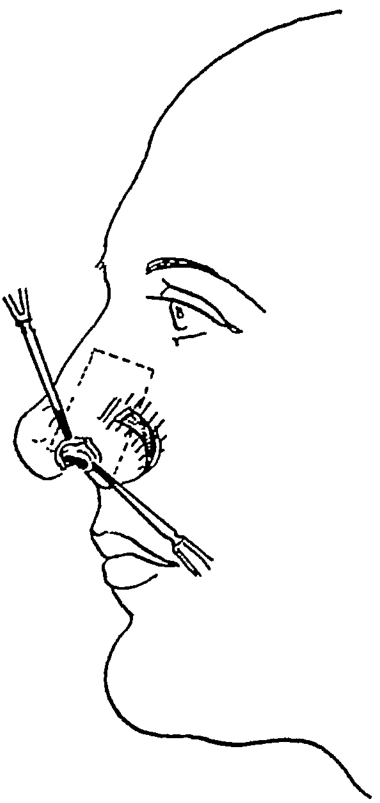


FIG 409 Secondary modeling following Lexer's operation Alar rim created by removal of section of bone through arched incision Alar groove constructed by excision of comma-shaped section of skin and subcutaneous tissue See also Figure 404.

The whole forehead flap is then bent in the form of a gable, rotated downward, and sutured to the freshened margins of the periosteum around the pyriform opening and to the denuded margins of the defect (fig 408-d)

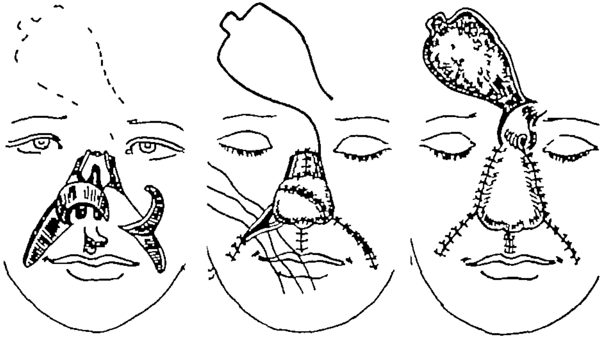
5 *Severance of Pedicle* After several weeks, when the nutrition of the flap has become established, the pedicle is cut and returned to the glabellar region

6 *Secondary Modeling* After healing is complete, the nose will appear thick and unshapely, but fortunately with this method there is sufficient material available to permit of secondary modeling First the depression along the rim of the nostril between the ala and the lobule is created by the excision of a semicircle of bone through a small incision along the rim just behind the tip (fig 409) Then the columella, which was formed from the skin on the inner surface of the forehead flap, is freshened at its

free extremity and sutured into a small wound prepared in the center of the upper lip above the nasal spine (fig 408-d) Should this flap be found too distorted or shrunken for use, a new columella may be formed according to another method of Lexer (p 806)

Joseph's Indian Method. Joseph's Indian method combines the best features of the original technics of Carpue, Dieffenbach, von Langenbeck Auvert, and Bardenheuer The successive steps are as follows (fig 410)

1 *Replacement of Lining* If the upper part of the nose is intact, the remaining skin is turned down, according to the method of Bardenheuer, in the form of a U shaped flap, and is used to replace the lining (fig 375) Should nasal skin be totally lacking or unusable, the lining is supplied by a forehead flap pedicled at the glabella and turned down, skin surface in, over the defect. Should the latter method be impracticable,



a b c

FIG. 410. Joseph's Indian rhinoplasty *a*, lining supplied by skin from upper nasal remnant and 2 turned-in nasolabial flaps. Columellar lining furnished by flap of skin from upper lip. Forehead covering flap indicated by dotted line. *b* lining flaps turned in and sutured together Secondary defects closed. Forehead flap raised. *c*, forehead flap rotated downward, to cover lining flaps Secondary forehead wound covered with skin graft.

two flaps pedicled at the alar margins and extending along the nasolabial grooves are turned up, skin surface in, and sutured to each other (fig 410-a)

2 *Replacement of Skin* An oblique forehead flap of the appropriate size, and with its pedicle just above the root of the nose, is outlined by an incision carried down to the periosteum, raised, and rotated into the nasal defect (fig 410-c) The residual wound in the forehead is closed either by approximating its borders after undermining, or by covering it with a skin graft. If the forehead skin is unsuitable for a covering flap, a facial flap pedicled along the nasolabial groove and directed diagonally toward the upper edge of the auricle is used instead (fig 411)

3 *Replacement of Framework* A normal profile projection is secured by the insertion of a suitable bone or cartilage graft into the soft tissues after they have completely healed (p 700)

Gillies' Indian Method Gillies (77) operates essentially as follows (fig 412).

1 *Establishment of Air Passages* The airways are re-established in the customary manner (p 771)

2 *Subcutaneous Implantation of Cartilage* Gillies prefers to implant subcutaneously three strips of cartilage cut to the required size and shape (fig 412-a) The section destined to form the future bridge is introduced beneath the forehead flap through a small incision between the eyebrows, those which are to form the alae are inserted beneath the skin of the cheek on both sides of the face above the upper lip "The cartilage may be put in prior to the rhinoplasty, into either the internal or the external flap or it may be interposed between the two flaps at the time, or subsequent to the rhinoplasty"

3 *Lining* After 3 weeks the nasal scar is excised and the edges of the wound pared The glabellar flap consisting of skin and the previously implanted cartilage is turned

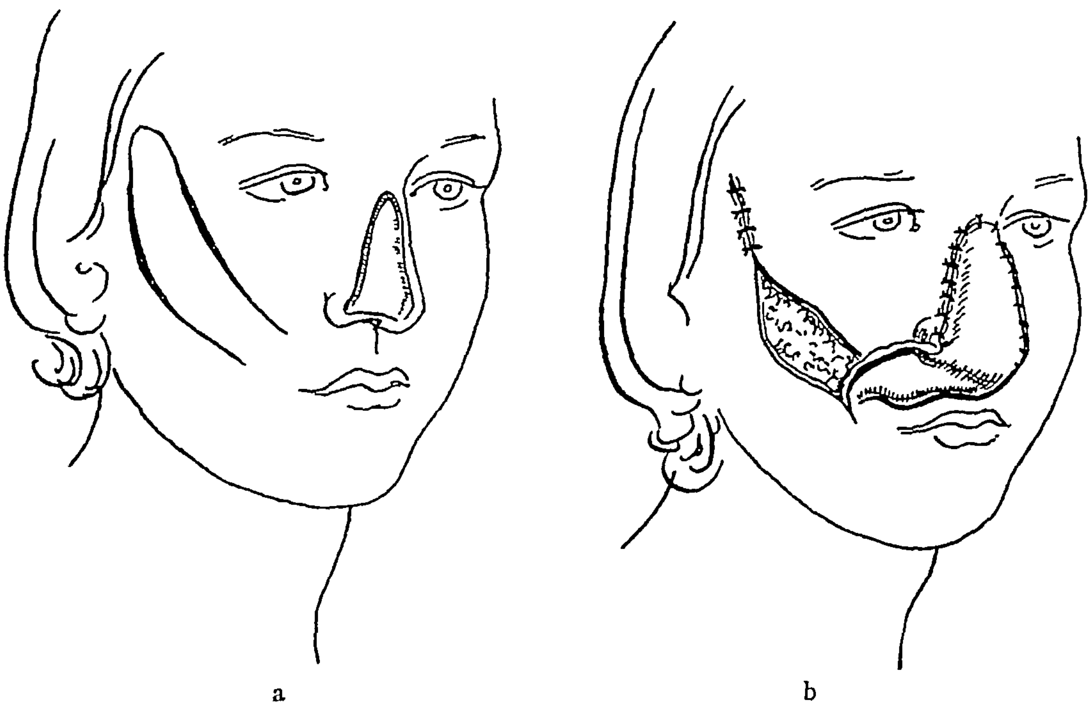


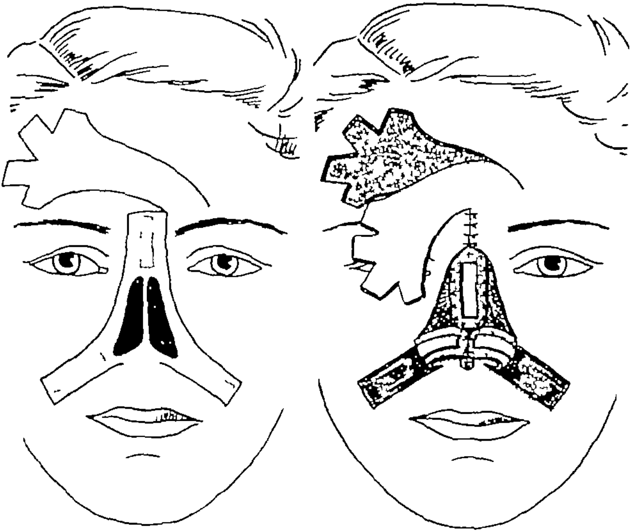
FIG 411 Use of facial flaps to supply cover *a*, flap outlined *b*, flap elevated and sutured in place Secondary wound approximated (Joseph)

down to form the lining and dorsal support of the nose, and the nasolabial flaps with their incorporated cartilages are turned inward to provide the alar portions of the lining (fig 412-b) The adjoining margins are united with catgut sutures placed in such a way that when they are tied the edges of the flap will be inverted (Lembert suture). Finally, any small defects still without lining are covered with small flaps turned in from the remaining margins of the defect

4 *Cover* The covering forehead flap is shaped in the form of a sickle The pedicle lies just above one eyebrow and the free end above the other (fig 412-a) The flap is raised in the usual manner, swung down, and accurately sutured to the margins of the raw area which have been slightly undercut The denuded surface on the forehead is covered with xeroform gauze, and a dressing is applied in such a way that it will not press on the pedicle After 3 weeks the pedicle is cut in the form of an inverted V and returned to the forehead

5 *Grafting of Secondary Defect* The granulations on the forehead are cleanly excised, and the area is covered with a full thickness skin graft.

Minor secondary operations will be necessary to give a definite outline to the nose. Should the dorsal arch be found too low, a piece of suitably shaped cartilage from the rib is inserted through a glabellar incision.



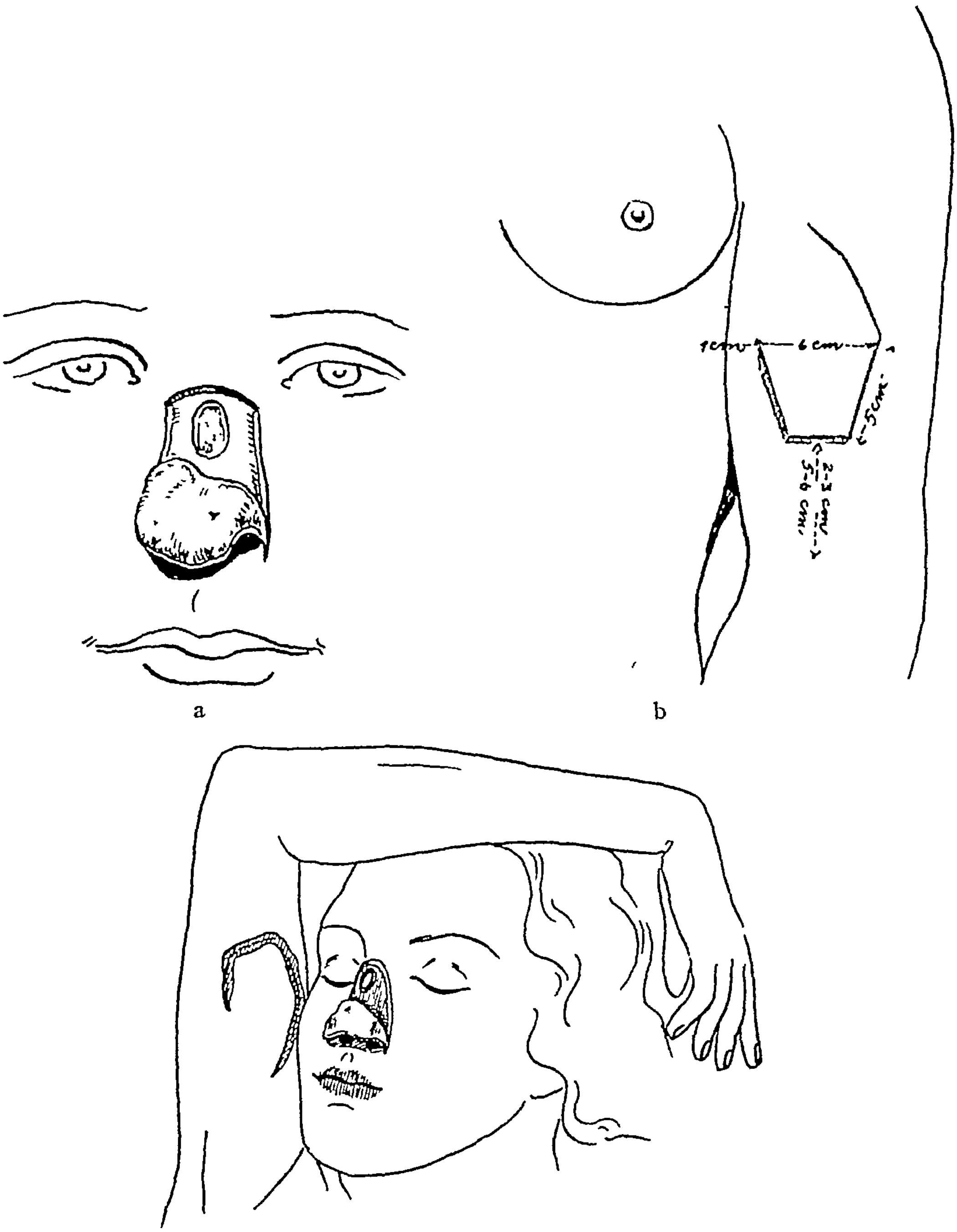
a b

FIG 412 Gillies Indian rhinoplasty *a*, dotted lines indicate 3 sections of cartilage implanted subcutaneously Section destined to form future bridge inserted through small incision between eyebrows. Those to form alae introduced beneath skin of cheek on both sides of face. Lining flaps on face and sickle-shaped covering flap on forehead outlined. *b*, lining flaps, incorporating previously implanted cartilage, turned in over defect and sutured. Forehead flap raised and sutured over newly formed lining. Secondary defects approximated or skin-grafted.

Modern Technic of Italian Rhinoplasty

Joseph's Italian Method. Joseph (133) preferred the use of an arm flap to supply the cover for the newly constructed nose, in that it did away with the forehead scar associated with the Indian method He simplified the previously complicated technic of fixation by incorporating in the plaster cast only the head and upper arm during the greater part of the immobilization period and thereby lessened the discomfort occasioned by the unnatural position of the arm and diminished the tendency to decubitus.

1 *Replacement of Lining* The lining membrane is restored by turning down the remaining skin of the nose A horizontal incision about 3 5 cm long is made over the root of the nose, and from either end of this incision a vertical incision is carried



a b c

FIG 413 Joseph's Italian rhinoplasty *a*, lining supplied by turned-down skin flap from nasal remnant Incision on one side extended only halfway to alar base, to insure maximum nutrition *b*, covering flap outlined on flexor surface of arm *c*, position of extremity for implantation of flap

downward along the nasofacial groove, one twice the length of the other, depending upon which arm is to be used to supply the cover For example, if the left arm is chosen, the incision on that side of the nose is extended only halfway to the base of the ala to allow for as broad a pedicle as possible and thereby assure maximum nourishment

to the flap On the right side the incision is prolonged to the alar base, and it is along this line that the corresponding border of the arm flap is to be sutured. The nasal flap thus outlined is separated from its underlying structures and turned down, wound surface out (fig 413-a)

When nasal skin is unavailable, lining may be supplied (1) by turning in adjacent cheek-skin flaps hinged on the borders of the defect, according to the technic of von Hacker and Thiersch (fig 390), (2) by turning down a forehead flap (fig 391), (3) by uniting a turned-down forehead flap with a turned in cheek flap (fig 391), or (4) by skin-grafting the under surface of the arm flap prior to transplantation

2 *Replacement of Skin Covering* The cover is supplied by a skin flap taken from the arm or forearm, the flexor surface of the arm being the site most frequently chosen. The flap is planned according to the size of the defect and corresponds roughly in out line to a figure 6 The pedicle is made to lie on the medial side of the arm, and the free end is directed downward and outward along the course of the brachial artery Joseph's technic is essentially as follows (fig 413 b) A horizontal incision 2 to 3 cm. in length is made on the flexor surface of the arm at a point 5 to 6 cm proximal to the flexure of the elbow in extension, and 2 to 3 cm. away from the flexure when the forearm is bent. From the outer extremity of this incision an arched incision about 10 cm. long and corre sponding to the long limb of the figure 6 is carried toward the shoulder From the inner end of the horizontal incision a straight incision about 5 cm. long and forming the short limb of the 6 is directed upward and inward the end of this limb lying about 1 cm. away from the medial margin of the arm in supination The greatest width of the flap should be equal to double the profile width of the nose—that is, about 6 cm. The skin flap thus outlined is detached from the underlying biceps muscle, with as little damage as possible to the blood supply The margins of the secondary wound on the arm are drawn together, and the remaining raw area is covered with a thick razor graft. The arm is then approximated to the face in such a manner that the forearm will be flexed across the top of the head the hand hanging down in back of the opposite ear (fig 413-c) The flap is sutured into the freshened nasal defect (fig 414-d)

3 *Immobilization* Immobilization is obtained by means of a plaster cast, the arm being secured to the head in such a way that there will be no tension on the pedicle. The bony prominences and ears are padded and the approximated parts enveloped in a bandage which leaves only the face exposed Over this bandage plaster of Paris is smoothly applied (fig 414-d) In 1 or 2 days large portions of the cast are cut away, exposing the fingers, wrist, and elbow, only that part which holds the arm to the head being left intact

4 *Implantation of Remainder of Flap* After the circulation in the flap has become established—a process which usually takes 2 or 3 weeks—the cast is removed. The pedicle is severed close to the arm (fig 414-e) and the extremity is gradually lowered. The short incision previously made on the nose is prolonged to the base of the ala, and the flap is sutured into the wound in the usual manner (fig 414-f)

5 *Restoration of Framework* Support for the dorsum and columella is supplied by means of a tibial graft. The piece of bone, having been procured (p 171) is divided into a long and a short section The larger piece is modeled to measure about 5 cm. in length, 1 cm in width and 6 to 8 mm. in thickness, and the smaller one 3 cm in length, 4 mm. in width and 3 mm in thickness. The periosteum is cross-hatched to

provide for better union with the overlying skin The long graft, which is to support the dorsum, is introduced into a previously prepared bed through an incision made over the glabella, and the shorter segment, destined to form the columella, is implanted

FIG 414 Joseph's Italian rhinoplasty (cont) *d*, arm flap sutured into freshened nasal defect Arm secured to head by plaster bandage *e*, two or 3 weeks later, donor pedicle severed close to arm *f*, remainder of flap sutured into defect

in a similar manner under the skin of the upper lip, so that one end will lie at the site of the proposed columella (fig 416-a)

At the end of 1 or 2 months a skin flap, containing the implanted bone graft, and with

its pedicle at the columella, is raised The free end is swung into a denuded area at the tip of the nose and attached with 1 or 2 sutures (fig 416-b) Joseph did not deem it advisable to force the columellar flap into a central position at this time, as the torsion necessary for the purpose might compress the pedicle and impair its circulation. The centralization of the columella is carried out more safely at a later date after healing has taken place. The secondary wound left in the upper lip is closed either by direct

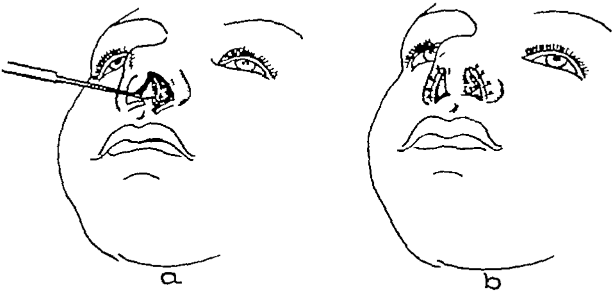


FIG. 415 Secondary modeling following Joseph's Italian rhinoplasty Formation of nostrils *a* skin flap raised from base of nose, pedicle lying at site of future columella Subcutaneous tissue removed. Another flap pedicled at ala cut from base of lip *b* flaps turned in to line septum and inner border of alar rim.

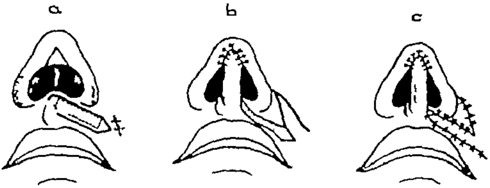


FIG 416. Secondary modeling following Joseph's Italian rhinoplasty (cont.) Formation of columella *a*, bone graft implanted beneath skin of lip one end lying at site of proposed columella indicated by dotted line. Flap destined to form columella outlined. Area below nasal tip denuded for reception of flap *b* skin flap containing implanted bone graft raised, rotated, and implanted in denuded area at tip Narrow nasolabial flap elevated to cover secondary defect. *c* skin flap sutured in place Tertiary defect closed by direct approximation of wound margins.

approximation of the margins or with a narrow nasolabial flap pedicled below at the margin of the defect (fig 416-c)

The nostrils are constructed as follows Two skin flaps are raised from the base of the nose, their pedicles lying on either side of the future columella. The subcutaneous tissue is removed, and the flaps are folded in to line the septum and held in place by means of a tampon (fig 415) The alar rims are formed by means of 2 additional

flaps, with their pedicles at the alae, raised from the base of the lip and sutured along the inner border of the alar rim

Gillies' acromiopectoral rhinoplasty is shown in Figure 417.

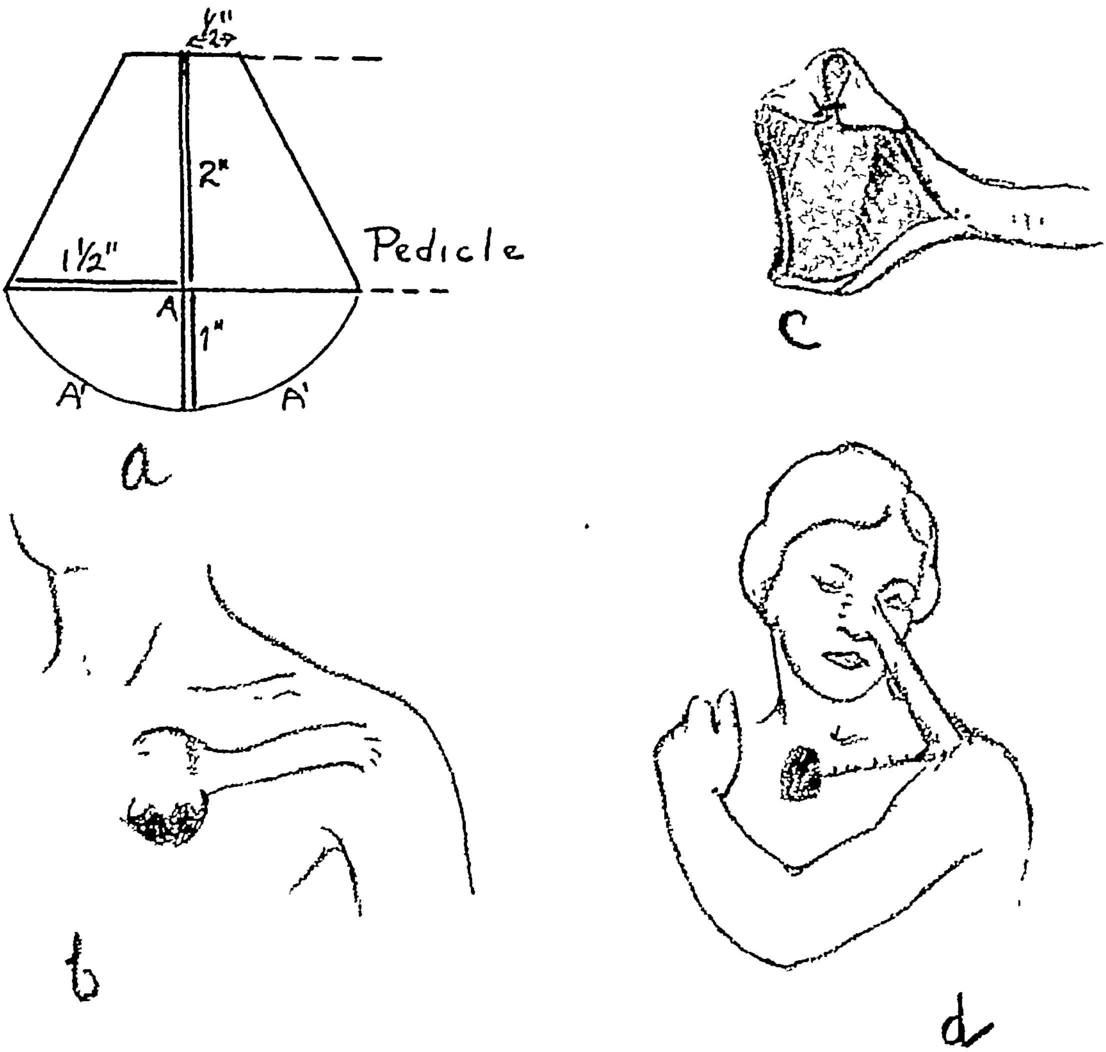


FIG 417 Gillies' acromiopectoral rhinoplasty *a*, diagram, showing dimensions of flap *b*, chest flap outlined Pedicle extended to acromial region Lower end of flap pinched in, to form alae and columella *c*, ental view *d*, flap transferred to pared margins of defect

PARTIAL RHINOPLASTY

A partial loss of the nose may involve cover, lining, and support, either singly or in combination The loss may be congenital, but is more often acquired as a result of trauma or disease The choice of the method to be employed will depend upon the site, shape, and extent of the deformity

Small losses, as a rule, may be corrected by shifting contiguous tissues into the defect, and when this is possible, it constitutes the most satisfactory means of reconstruction In the case of larger defects, provided the destruction is limited to one layer only, the loss can be replaced with a graft, but where two or more coats are involved, flaps must be used They are preferably taken from adjacent areas, such as

the lip, cheek, or forehead, but when these tissues are inadequate or unusable because of scars or disease, material must be transported from a distance.

As has been said before in the section dealing with total rhinoplasty, lining, cover, and support must all be restored. Failure to replace any one coat will inevitably cause contraction and distortion and invalidate the initial benefits of the reconstructive procedure.

Reconstruction of Alae

With the possible exception of the auricle, no part of the body is so difficult to restore as the alae. The difficulty lies in securing a double-lined flap capable of circumscribing the nares symmetrically and keeping them patent. The repair will be greatly simplified if at the border of the nostril even a small remnant of alar tissue remains to which a flap may be attached. Therefore, in traumatic injuries or in the removal of tumors,

FIG. 418. Correction of extensive alar defects. Lining provided by nasolabial flap pedicled on margin of defect (von Hacker). Cover supplied by oblique flap from dorsum pedicled at inner canthus with free extremity on opposite ala (von Langenbeck).

as much alar tissue as possible should be preserved. Small losses may be replaced by advancement or rotation of contiguous tissues; for more considerable defects material must be secured from the forehead, ear, or arm. Lining is supplied by skin-grafting the under surface of the flap.

Reconstruction by Use of Nasal Tissue. If the ala is slightly elevated as a result of scar contraction or partial loss, Dieffenbach's (45) V-Y advancement method is frequently effective (fig. 368). Immediately above the defect an inverted V-shaped incision is made through the entire thickness of the nasal wall. The skin around the incision is undermined, and the base of the V is drawn down for a distance sufficient to overcome the deformity. The margins of the remaining wound are coapted from above downward, the inverted V being transformed into an inverted Y.

For the correction of high and narrow alar defects von Langenbeck employed the following method (fig. 418). A flap was outlined obliquely across the dorsum, with its pedicle in the vicinity of the inner canthus on the side of the loss and its free extremity lying on the opposite ala. The flap, consisting of skin only in its upper part and of

the full thickness of the nasal wall at its free extremity, was raised and rotated into the pared defect and sutured in place The secondary wound was closed by direct approximation of the margins

For a more extensive loss of alar tissue von Hacker (91) employed the covering flap of von Langenbeck, but provided a lining by turning in a nasolabial flap pedicled on the margin of the defect (fig 418).

To repair a moderate defect of the alar rim in a broad nose, Joseph (133) operated as follows (fig 419) An incision was made, beginning at the anterior part of the defect and carried upward along the side of the dorsum for about two-thirds of its extent, penetrating the full thickness of the nasal wall From the upper extremity of the first incision a second incision was carried along the posterior margin of the defect to the upper part of the rim The acute triangle of tissue thus outlined was removed The

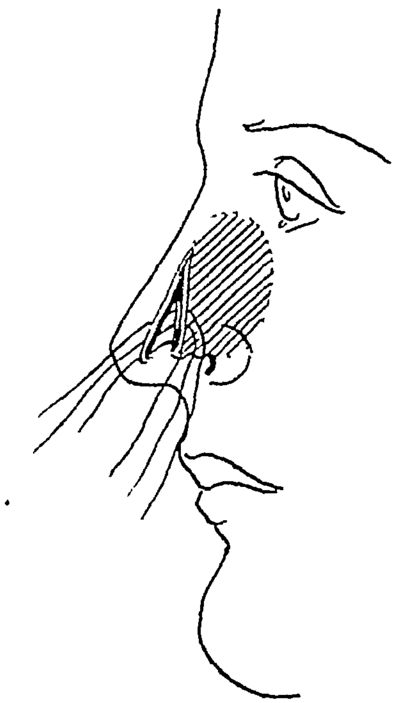


Fig 419 Correction of defect of alar rim associated with broad nose Margins of defect pared, to form triangle Skin undermined, as indicated by shaded area Wall of nose mobilized and displaced downward Wound margins united (Joseph)

skin was undermined above as far as the inner canthus, laterally to the nasomaxillary junction, and below to the alar rim The wall of the nose was then displaced downward, and the wound margins were united

In the case of alar losses involving the entire outer rim, Denonvilliers' (42) operation may be employed to advantage (fig 420). A flap consisting of the full thickness of the nasal wall, with its pedicle at the alar-facial junction and its lower border constituting the defective alar rim, is lowered and sutured into its proper location in the lobule The secondary wound is closed with a flap taken from the anterior part of the nose and with its pedicle below If the rim elevation is greater posteriorly than anteriorly, the operation of Denonvilliers may be reversed, the pedicle being placed anteriorly (fig 421) The flap thus mobilized is drawn down to the required position and sutured into the pared margin of the defect The secondary wound is closed by means of a skin flap with its pedicle in the bucconasal region and its apex directed inferiorly

The auricular transplant is cut from the full thickness of the helix (fig 429), the size and shape of the section corresponding to the dimensions of the loss. The graft is sutured to the pared margins of the defect in layers, the skin on the outer surface of the graft being united to the skin and that on the inner surface to the mucous membrane of the nose

To minimize the auricular deformity arising from the above procedure, the graft may be procured as follows A section of skin and cartilage of an appropriate size and

FIG 427 Reconstruction of alar loss by use of cheek flap a, nasolabial flap turned in, to furnish lining b dark dotted lines show outline of cheek flap Light dotted lines, amount of undermining c, cheek flap advanced over defect and sutured in place.

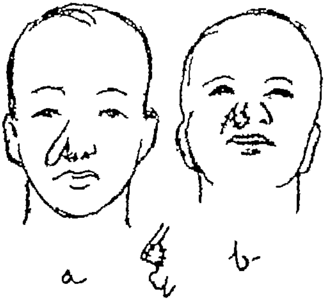


FIG 428 Reconstruction of alar loss by use of nasolabial flap a flap outlined b flap turned in and sutured to pared margins of defect. Insert shows turned in flap (Pierce and O'Connor)

shape is removed from the posterior aspect of the auricle, the skin on the anterior surface of the ear being left intact. The graft is cut in such a manner that a fringe of skin is left extending beyond the cartilage. Lining is supplied by turning down a skin flap pedicled at the margin of the defect (fig 430) and implanting the graft in the usual manner Goecke (79) cut from the rim of the nostril a flap pedicled posteriorly, brought it down sutured it into the lobule, and implanted the graft into the wound thus created (fig 431)

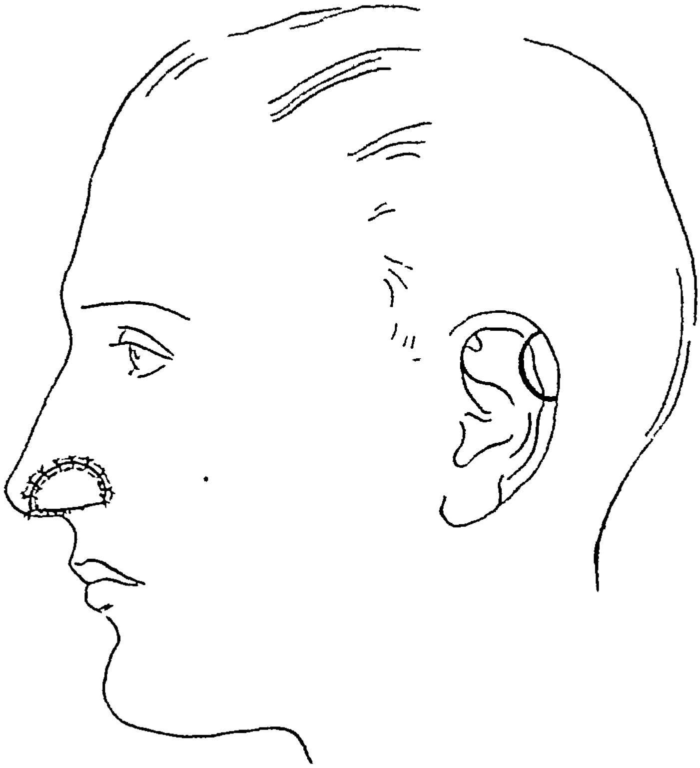
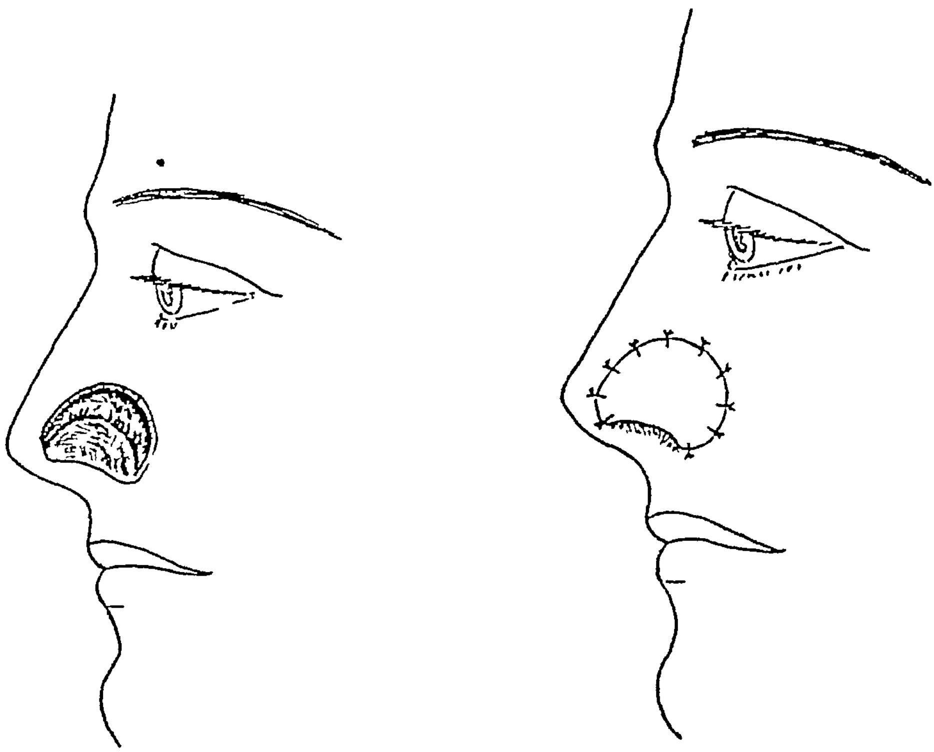


FIG 429. Reconstruction of ala with auricular tissue Edge of defect pared Semilunar section of helix, corresponding in size and shape to defect, removed and sutured in place (Koenig) (While the helix is particularly adapted for replacement of alar losses, 50 per cent of such grafts fail, due to narrow margins of approximation)



a b

FIG 430 Reconstruction of ala with auricular tissue a, lining supplied by skin flap turned down from margin of defect b, postauricular graft composed of skin and auricular cartilage sutured in place (Schroeder-Joseph-Lexer) (This type of graft minimizes auricular deformity, and broad surface contact enhances viability of graft.)

To increase the viability of the transplanted tissue, Krestovickij (*152*), Trofimov (312), and Ivanissevich (125) transported the auricular tissue to the nose in the form of a flap A tubed flap was formed in an appropriate location, one extremity terminating in the auricle. After vascularization had taken place, a portion of the required size

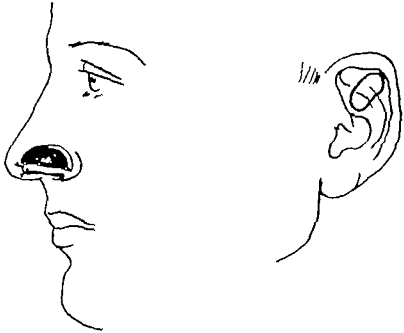


FIG. 431 Reconstruction of ala with auricular tissue. Full thickness alar flap, pedicled posteriorly brought down and fixed to lobule Resultant defect filled by auricular graft. (Goecke)

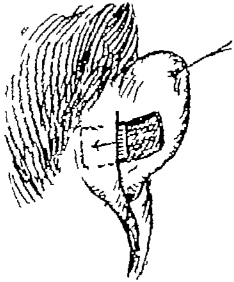
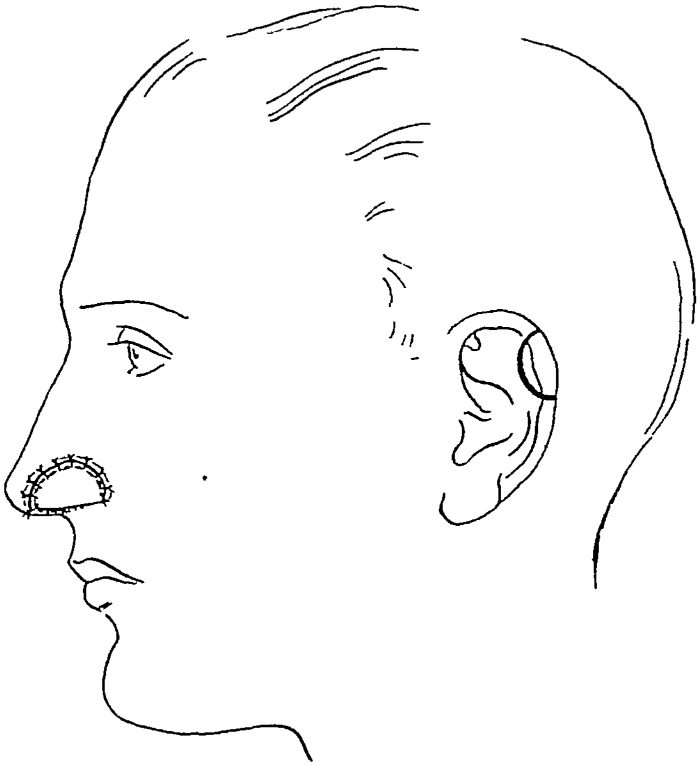


FIG 432. Reconstruction of ala with auricular tissue. Flap of ear cartilage and postauricular skin implanted beneath upper end of tubed cervical flap. After vascularization, upper pedicle severed and end of flap containing implanted cartilage swung into pared margins of alar defect. (This mode of transfer enhances viability of graft.)

was removed from the ear and transferred on the pedicle to the defect (fig 432) Ivanissevich (123) used the thumb as an intermediate carrier to transfer the auricular transplant to the defect.

Reconstruction by Use of Forehead Skin. The alae may be repaired by skin flaps



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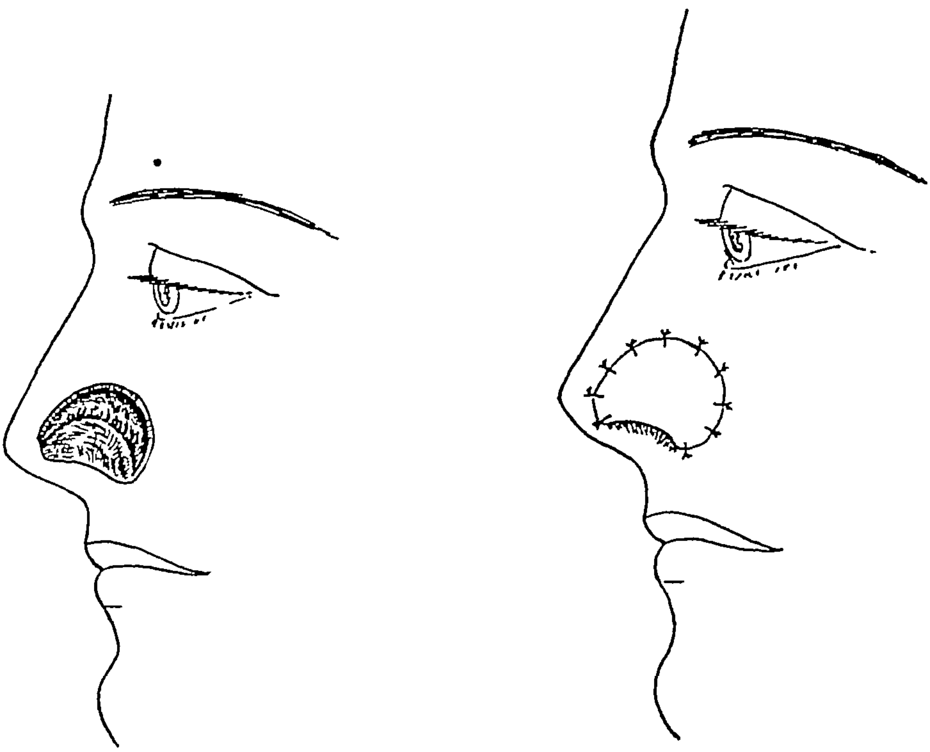

a b

FIG 430 Reconstruction of ala with auricular tissue *a*, lining supplied by skin flap turned down from margin of defect *b*, postauricular graft composed of skin and auricular cartilage sutured in place (Schroeder-Joseph-Lexer) (This type of graft minimizes auricular deformity, and broad surface contact enhances viability of graft)

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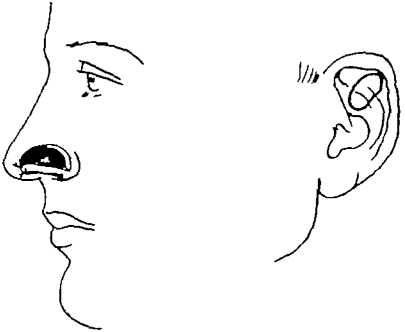


FIG 431 Reconstruction of ala with auricular tissue. Full thickness alar flap, pedicled posteriorly, brought down and fixed to lobule. Resultant defect filled by auricular graft. (Goecke)

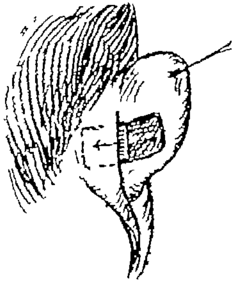


FIG 432 Reconstruction of ala with auricular tissue. Flap of ear cartilage and postauricular skin implanted beneath upper end of tubed cervical flap. After vascularization, upper pedicle severed, and end of flap containing implanted cartilage swung into pared margins of alar defect. (This mode of transfer enhances viability of graft.)

was removed from the ear and transferred on the pedicle to the defect (fig 432). Ivanissevich (123) used the thumb as an intermediate carrier to transfer the auricular transplant to the defect.

Reconstruction by Use of Forehead Skin. The alae may be repaired by skin flaps

taken from the forehead Lining is supplied either by turned-in skin flaps pedicled on the margins of the defect or by grafting the under surface of the forehead flap (fig 433)

Reconstruction by Tissues Taken from a Distance While replacement of nasal losses with tissue taken from a distance obviates additional scarring of the face, the skin does not match that in the recipient area and even after years stands out as a glary white patch Nevertheless, the procedure must be resorted to when contiguous tissues are unavailable A flap corresponding to the dimensions of the contemplated ala is raised in an appropriate location on the forearm, and its under surface is epithelized either by means of a razor graft or by folding the flap on itself At a later stage the margins of the defect are denuded, and the flap is sutured into place after

FIG 433 Reconstruction of full thickness alar loss with flap taken from forehead Lining supplied by turned-down skin flap hinged at margin of defect Cover flap outlined on forehead

the arm has been approximated to the head At the end of 10 days the pedicle is severed, and the balance of the flap is fitted into the defect The required consistency is secured by the implantation of a segment of cartilage The repair may also be carried out with abdominal skin, the hand being used as a carrier

Reconstruction of Lobule

The lobule may be partially or completely destroyed, the loss involving skin, cartilage, or mucous membrane, alone or in combination As in the case of alar losses, reconstruction is accomplished by the use of tissues taken from the nose, cheek, forehead, or arm Skin losses may be replaced with skin grafts taken from the upper eyelid or

from behind the ear When lining and support have likewise been destroyed the reconstruction is best accomplished by means of skin lined forehead flaps, the supporting structure being replaced with cartilage obtained from the ear or rib

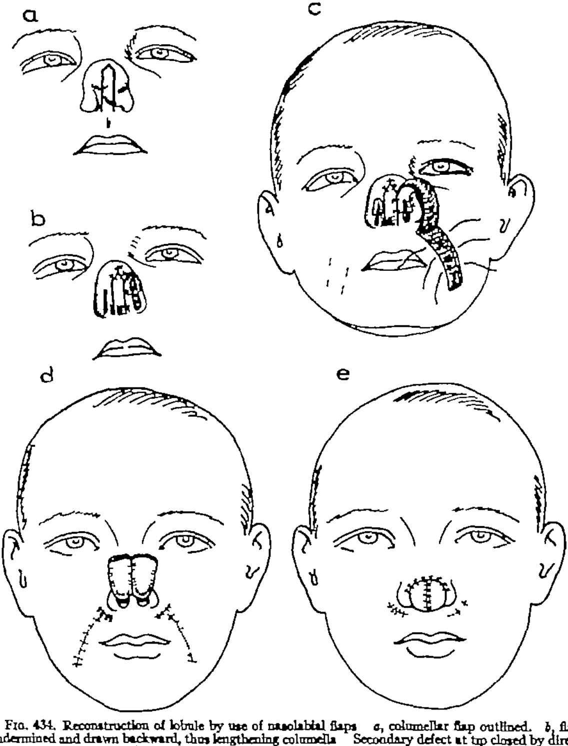
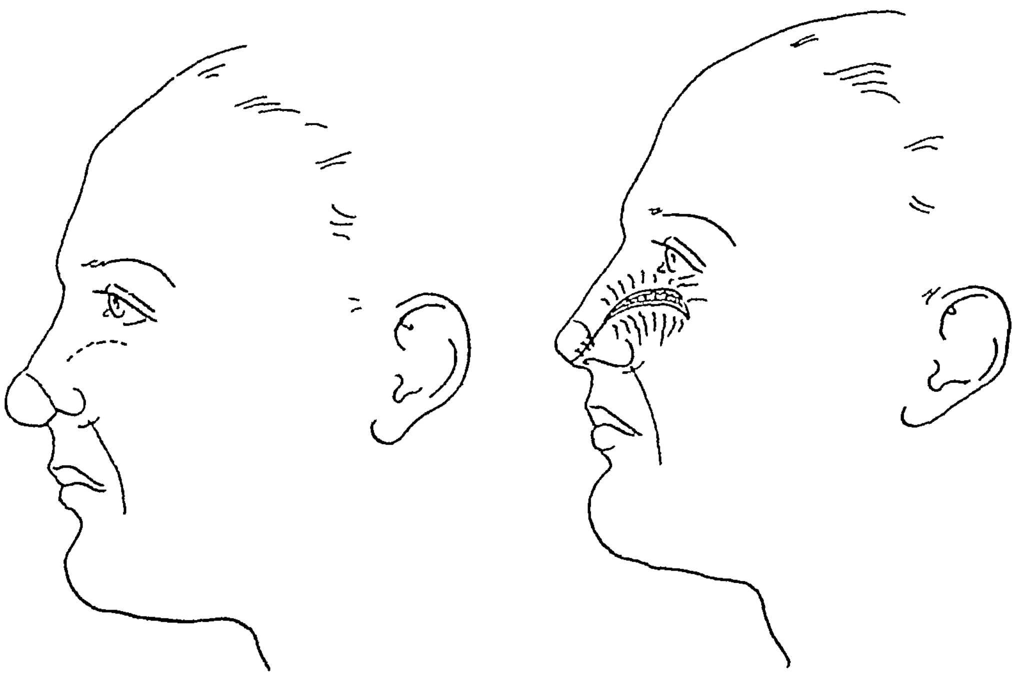


FIG. 434. Reconstruction of lobule by use of nasolabial flaps *a*, columellar flap outlined. *b*, flap undermined and drawn backward, thus lengthening columella Secondary defect at tip closed by direct approximation. Nostril defect pared for reception of flap *c*, nasolabial flap on one side raised, turned upward, raw surface out, and free end sutured into pared nostril defect. Secondary nasolabial wound closed by direct approximation. Dotted line shows flap to be raised on opposite side. *d*, at another stage, pedicles of nasolabial flaps cut. Flaps turned on themselves medially *e*, flaps denuded at points of contact and sutured together Upper margins of flaps united to pared defect.

Reconstruction by Use of Auricular Tissue Grafts taken from the concha have been employed for the reconstruction of the lobule. Although this method requires

less time than when flaps are used, it has the same disadvantages as when employed for the replacement of lost alar tissue

Reconstruction by Use of Nasolabial Flaps If the loss involves the full thickness of the tip and there is an associated distortion of the columella and alae, the use of nasolabial flaps as advocated by Réthi (253) frequently offers a satisfactory solution to the reconstructive problem (fig 434) The first step contemplates lengthening of the columella Two incisions are made on either side of the distorted columella, meeting in a point at the apex of the lobule (fig 434-a) The flap thus outlined is undermined and drawn backward The residuary wound in the tip is closed by direct approximation (fig 434-b) To reconstruct the alae, 2 nasolabial flaps 2 cm wide and with their pedicles at the bases of the alae and their free ends extending below the corners of the mouth are raised (fig 434-c) These flaps are turned upward, raw surfaces out, and their

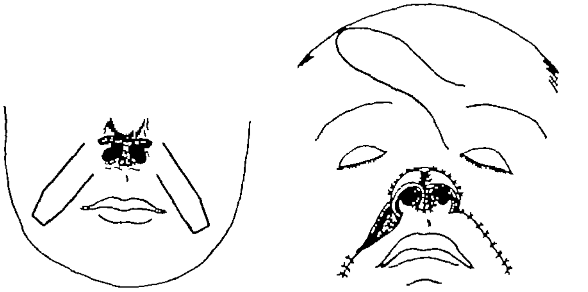


f g

FIG 435 Reconstruction of lobule by use of nasolabial flaps (cont) *f*, dotted lines indicate arched incision for mobilization and readjustment of tissues *g*, skin undermined, parts readjusted, and margins approximated (Réthi)

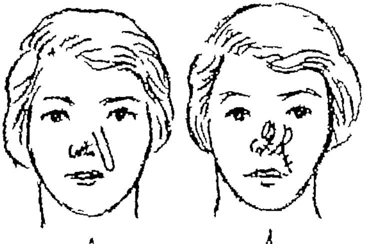
free ends are sutured into the pared nostril defects (fig 434-c) The secondary nasolabial wounds are closed by direct approximation (fig 434-d) The flaps are then allowed to undergo cicatrization, so that they will assume a more rounded contour After a lapse of 4 weeks the pedicles are cut, turned medially on themselves, and gradually drawn upward with adhesive tape In about 3 weeks the 2 flaps at the points where they appose one another are denuded and united by fine sutures At the same time the skin of the dorsum is freshened and the upper edges of the flaps united to it (fig 434-e) At a later stage the grooves between the tip and the alae are corrected Arched incisions are made, extending from the foremost parts of the grooves across the sides of the nose and ending below the outer canthi (fig 435-f) The tissues are undermined, readjusted in their normal relations, and the margins are approximated with horsehair sutures (fig 435-g).

The Thiersch Bayer Payr procedure is carried out as follows (fig 436) Two nasolabial skin flaps, with their pedicles at the alae and their free extremities lying below the corners of the mouth, are raised (fig 436-a), the *width* of each flap being equal to the required length of the nose and the *length* being sufficient to form nostrils, columella and alae of the proper size The flaps are turned upward and inward in such a way



a b

Fig. 436. Reconstruction of lobule with nasolabial flaps for lining and forehead flap for cover *a*, two nasolabial flaps outlined. Stump of nose freshened for reception of flaps. *b* flaps turned upward and inward to line vestibule, and secured to prepared area at base of upper lip and to each other (New columella formed by lower borders of adjacent raw surfaces of flaps.) Upper borders of flaps sutured to pared margins of dorsal defect. Secondary nasolabial wounds closed. Forehead flap outlined for cover (Thiersch-Bayer Payr)



a b

Fig 437 Reconstruction of lobule by use of nasolabial flap *a*, flap outlined *b*, flap raised and sutured into pared margin of defect. Gauze roll placed beneath flap (Pierce and O Connor)

that their skin surfaces form a lining for the vestibule and are secured to the upper lip and to each other (fig 436-b) The lower borders of the adjacent raw surfaces of the flaps form the columella, as indicated in the diagram. The upper borders are then sutured to the pared margin of the defect, and the secondary nasolabial wounds are closed The skin covering is replaced with a flap taken from the forehead or arm (7)

Pierce and O'Connor (246) reconstructed a deformity involving a loss of the nasal tip, left ala, and columella by means of a descending flap from the nasolabial fold Figure 437 is self-explanatory For the repair of larger defects they raise a tubed

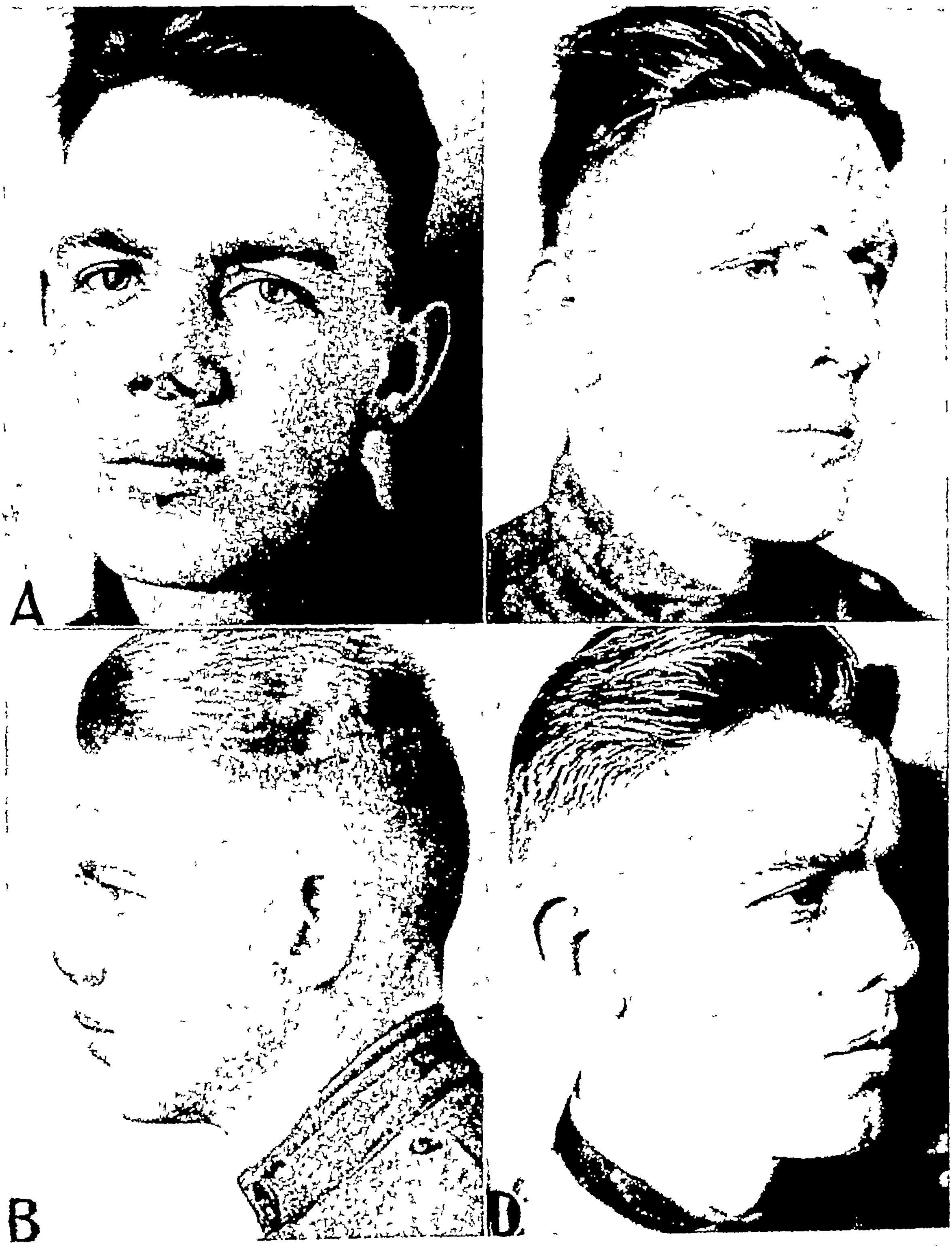


Fig 438 Reconstruction of lobule by use of forehead flap *a*, loss of nasal tip—frontal view *b*, profile view. *c*, forehead flap sutured into pared defect *d*, pedicle severed and returned to forehead. (Medical Dept, U S Army, Vol. XI)

flap parallel to the clavicle and step it up at intervals of 3 weeks, until it can be brought into the area to be reconstructed

Reconstruction by Use of Forehead Flaps. A lost lobule may be replaced with a forehead flap its pedicle lying between the eyebrows and its free end shaped to correspond to the defect. Lining is supplied by means of a nasolabial flap or by skin grafting the under surface of the covering flap (fig 438)

Reconstruction by Use of Arm Flaps. Reconstruction of the lobule by the use of an arm flap assures satisfactory results with a minimum of scarring, but the color match leaves much to be desired. Ombrédanne (236) employing this type of flap corrected a defect of the lobule in the following manner A flap was outlined on the anterior surface of the arm or forearm its pedicle directed toward the wrist. The free end of the flap was of sufficient size to permit of its being turned in to serve as lining The flap was raised and sutured into the pared margins of the defect. After 10 to 14 days the pedicle was cut. Several weeks later the edges were turned under to line the nostrils, and the columella was formed and attached to the upper lip

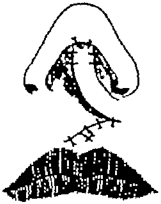


FIG 439 Reconstruction of columellar skin loss with labial tissue. a, flap raised from upper lip and attached to prepared area at nasal tip. Margins of secondary wound approximated directly At later stage, pedicle cut and implanted into prepared bed in lip. (von Langenbeck)

Reconstruction of Columella

Partial Loss. Columellar defects limited to a destruction of the skin and not associated with a depressed lobule may be repaired with a skin graft on a stent mold or with a flap

Von Langenbeck outlined a semilunar flap on the lip, with its pedicle directed laterally and its free end curving toward the center of the vermilion border The flap was raised rotated and sutured into a prepared wound at the tip of the nose. The margins of the secondary defect in the upper lip were approximated directly When union had taken place, the pedicle of the flap was severed and sutured into a bed prepared for it in the upper margin of the lip (fig 439) Blasius (15) outlined a skin flap on the upper lip with its pedicle on the philtrum and its free end directed laterally The flap was raised and the extremity sutured into a pared area on the nasal tip The secondary wound in the lip was closed by approximation of the skin margins (fig 440) Serre (287) also employed a philtrum flap, with its base at the vermilion border The free end was united to the lobule, and after healing had taken place, the pedicle was severed

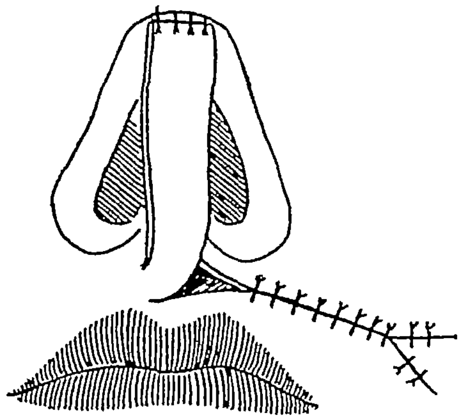


FIG 440 Reconstruction of columellar skin loss with labial tissue Upper lip flap, pedicled on philtrum, attached to nasal tip Secondary wound closed directly After vascularization, pedicle cut and fitted into base of lip (Blasius)

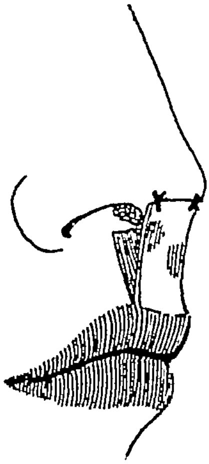


FIG 441 Reconstruction of columellar skin loss with labial tissue Philtrum flap, pedicled on vermilion border, raised Free end attached to prepared area in nasal tip At later stage, donor pedicle cut and attached to upper lip (Serre) (Flaps in Figures 439–441 may also be used to replace total columellar losses by first skin-grafting their under surfaces)

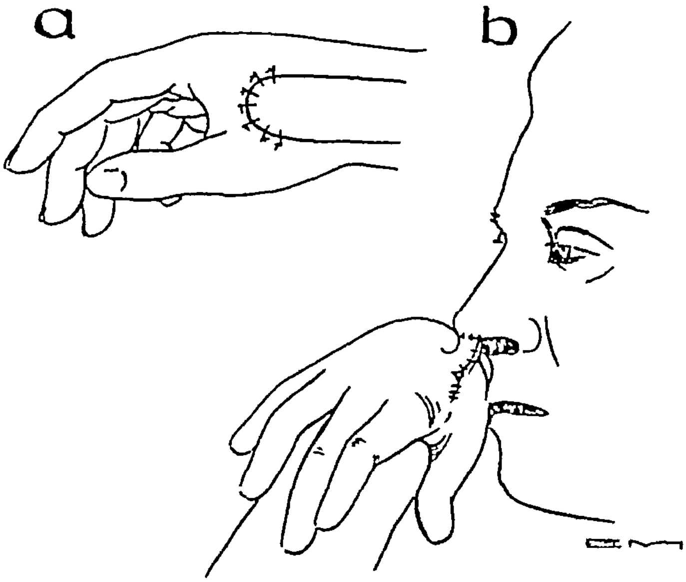


FIG 442 Reconstruction of columellar skin loss with tissue taken from hand *a*, flap raised and resutured in original bed, to enhance circulation *b*, at second stage, flap raised and sutured to prepared area on nasal tip After vascularization, donor pedicle cut and attached to base of lip

and the base attached at the nasolabial junction (fig 441) Repair by a skin flap taken from the hand is shown in Figure 442

Total Loss. When the columella has been totally destroyed, it can be replaced with tissues taken from the nose, lip, or forehead (figs. 443–445) The supporting structure

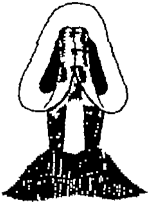


FIG. 443. Reconstruction of total columellar loss with labial tissue. Two flaps, pedicled at base of lip, raised from either side of philtrum and folded lengthwise on their raw surfaces, to form doubled skin flaps. Raw edges approximated, and free end of doubled flap sutured to prepared defect at nasal tip. Cartilage graft inserted beneath skin surfaces after healing (Demons)

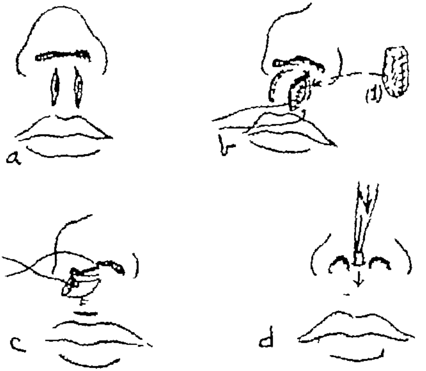


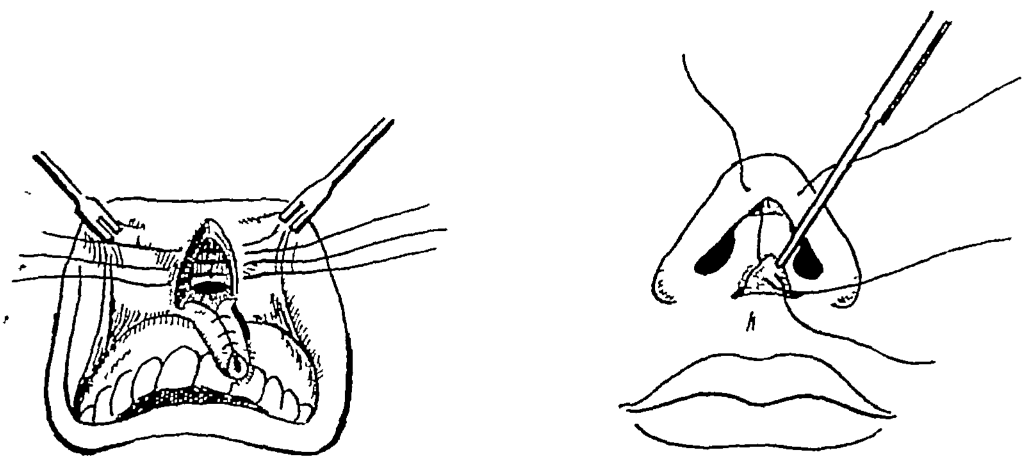
FIG. 444 Reconstruction of columella with lined philtrum flap. *a*, philtrum flap outlined by 2 parallel incisions. *b*, double-pedicled skin flap raised. Full thickness skin graft on stent mold *1* inserted beneath it. *c* after vascularization, mold removed. Lower pedicle of lined flap severed and attached to pared area on nasal tip. First suture placed *d* cartilage graft implanted, to furnish support. (New and Figi)

may be implanted into the flap either before it is rotated or after it has healed in its new location

Reconstruction by Use of Labial Tissue Demons (40) outlined two lip flaps, one on either side of the philtrum, their pedicles lying at the base of the lip and their free

ends at the vermilion border The flaps were raised and folded lengthwise on their raw surfaces, so that two doubled skin flaps were formed The raw edges of these flaps were apposed to each other and approximated by sutures (fig. 443). The free end of this doubled flap was then sutured into a prepared defect at the tip of the nose After healing had taken place, some secondary modeling was done, and a piece of cartilage was inserted between the two skin surfaces to furnish the necessary rigidity

Joseph (133) constructed a columella in the following manner (fig 416) A graft of the proper size was taken from the tibia and implanted under the skin of the lip at the site of the proposed flap When the bone had become established in its new location, the under surface of the proposed flap was skin-grafted The epithelized flap was raised and united to the margins of a prepared wound at the tip of the nose Subsequently, the columella was brought to the midline by means of a Z-plastic operation (fig 361) The objection to this procedure is the tendency on the part of the lip to become everted, and in men the hairiness of the skin



a b

FIG 445 Reconstruction of columella with buccal tissue *a*, upper lip everted Tongue-shaped flap, pedicled at gingivolabial fold, raised and tubed Sutures placed for closure of secondary wound *b*, tubed mucosal flap drawn through transverse incision made on line designated to become base of new columella Flap sutured to denuded area just below nasal tip At later stage, cartilage graft from septum or ear introduced, to furnish support (Lexer)

New and Figi (227) reconstruct the nasal columella by means of a lined flap taken from the upper lip, as shown in Figure 444

Reconstruction by Use of Buccal Tissue Lexer (169) used a tubed flap of mucous membrane, thus (fig. 445): With the upper lip everted, a tongue-shaped flap of mucous membrane is outlined, its pedicle lying at the gingivolabial fold and its free end reaching almost to the vermilion border The flap is raised and tubed A transverse incision about 1 5 cm in length is then made in the skin of the upper lip on a line designated to become the base of the new columella Through this slit the previously tubed fold of mucous membrane is drawn and sutured to a pared area just below the tip of the nose The necessary support is introduced at a later stage in the form of an appropriately shaped piece of cartilage obtained from the septum or ear.

Reconstruction by Use of Forehead Tissue Hildebrand (106) was the first to form a columella from the frontal bone, thus. A flap is outlined on the forehead above and between the eyes in the form of the letter T At the center of the horizontal bar

a small piece of bone is chiseled from the outer plate of the frontal bone. The T-shaped flap is raised. The skin margins of the horizontal bar are folded under to cover the bone graft. When healing has taken place, an incision is made across the upper third of the nasal dorsum, and the flap is drawn through it. One border of the flap is sutured to the base of the nose and the other is fixed to the freshened inferior margin of the tip After the flap has become organized in its new location, the pedicle is cut. Rubber tubes are inserted into the nostrils for the double purpose of drainage and shaping

Reconstruction of Septum

A perforation in the lower part of the septum can be obliterated by raising a double-pedicled flap of mucosa above the loss, shifting it downward, and suturing it to the lower margin of the defect (fig 345) In the case of a fresh perforation Seiffert (283)

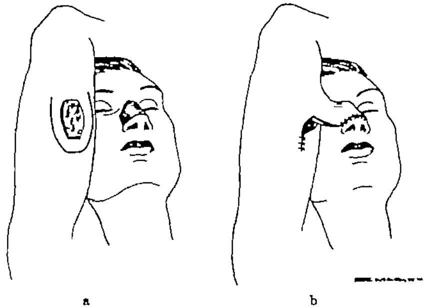


FIG 446 Replacement of nasal skin with flap taken from arm. *a* flap outlined excised scar serving as pattern. *b* flap sutured in place.

employs the tissue of the concha to close the opening, thus After denuding the margins of the perforation and the concha he secures approximation of the raw surfaces by packing the opposite nostril with a tampon. When healing has taken place, he separates the concha and septum and allows the raw areas to granulate (fig 346)

Reconstruction of Osseous and Upper Cartilaginous Vaults

The reconstruction of partial defects of the osseous and cartilaginous vaults will be considered simultaneously since the methods of reconstruction are identical. As in the case of the lower cartilaginous vault, the loss may involve skin framework, and mucous membrane either singly or in combination. Skin may be replaced with grafts or with flaps from the forehead, nasolabium or arm (fig 446), support is obtainable from cartilage transplants and lining may be supplied by flaps of adjacent skin pedicled at the margins of the defect and turned skin side in by mucous membrane flaps secured from the septum or by skin-grafting the under surface of the covering flap

Defects of the upper and middle sections of the nose can be reconstructed with a nasolabial flap pedicled at the margins of the loss, the skin around the wound being

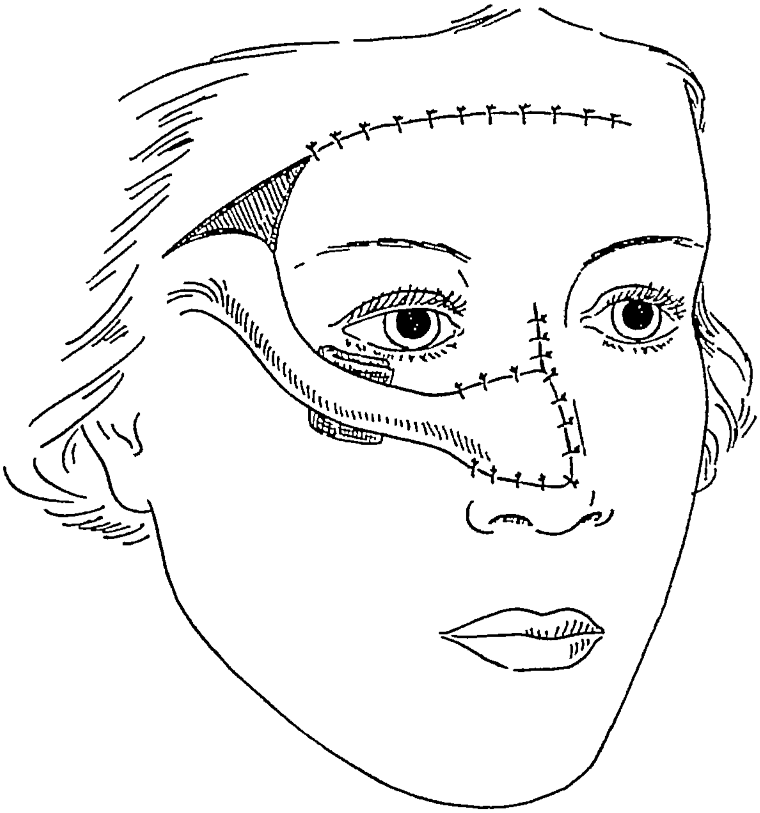


FIG 447 Repair of dorsal defect by use of tubed forehead flap pedicled on temporal artery

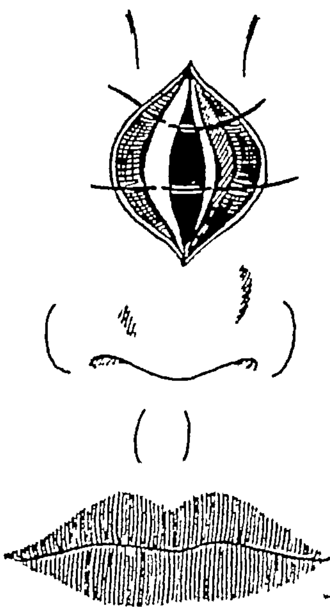


FIG 448 Repair of dorsal defect involving full thick... Skin along margins of defect turned in hinge-fashion, to form ... Adjacent skin u... d advanced, to supply cover (Joseph)

turned in to serve as lini... nasolabial ... mployed ... turned in to form the lining and th... over it to ... in co... e use of a tubed pedicle flap fro... is frequ... satisf... ns of

correcting these defects (fig 447) Joseph (133) repaired a dorsal defect involving the full thickness of the nose by turning in hinge-fashion the skin of the wound margins

FIG. 449 Reconstruction of nasal dorsum with forehead flap. Support furnished by costal cartilage implant. (Medical Dept. U S Army Vol. XI)

to form a lining and replaced the cover by undermining and advancing the adjacent skin (fig 448) Support was provided by means of a cartilage implant after healing had taken place Repair by the use of a forehead flap is shown in Figure 449

To replace a small loss involving the full thickness of the nasal wall, de Quervain (250) swung a portion of the full thickness of the septum hinged on the dorsum into the defect, thus supplying the mucous membrane lining For cover he used a flap taken from the vicinity (fig 450) Kazanjian's method is shown in Figure 451.

A total loss of the middle portion of the nose was replaced by Joseph (133) as follows (fig 452). A horizontal incision was made across the dorsum above the lower

FIG 450 Reconstruction of nasal lining with flap taken from full thickness of septum. *a*, shows defect and outline of septal flap Lightly dotted line, outline of septal incision, dark dotted line, position of flap when in place *b*, sectional view at level of defect, showing full thickness septal flap hinged on nasal dorsum, swung across defect, and attached to margins of loss Cover supplied by skin flap taken from vicinity (de Quervain)

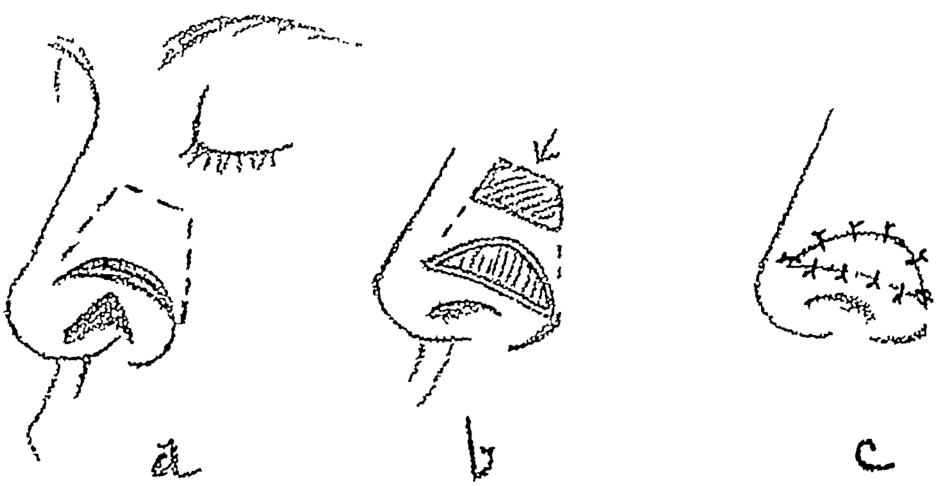


FIG 451 Reconstruction of alar loss *a*, scar tissue removed, and skin undermined Mucous membrane incised under nasal bone *b*, mucous membrane drawn down, to serve as lining *c*, outer raw surface covered with skin graft (Kazanjian)

cartilaginous vault and carried through the entire thickness of the nose The lower segment was drawn down to its proper level Mucous lining was provided by means of a flap turned down from the upper part of the nose, with its pedicle on the border of the defect For cover a skin flap secured either from the forehead, cheek, or arm was employed The particular objection to this procedure is the proneness of the lining flap to undergo necrosis because of the torsion on its pedicle

Watts (328) employed the fifth finger to replace the middle section of a nose destroyed by gunshot injury After denuding the small finger of the left hand, he inserted it into the defect through an incision in the columella. The parts were im mobilized in a plaster cast After organization had taken place, the finger was amputated, and the columella was sutured over the end of the severed digit.

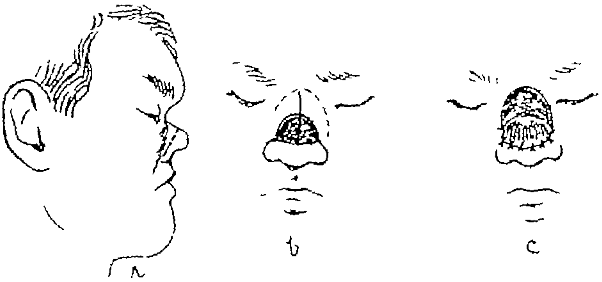


FIG. 452. Reconstruction of total loss of middle third of nose. a horizontal incision made across entire thickness of nose. b lower segment brought down to proper level c, lining supplied by turned-down flap from upper remnant of nose skin cover by forehead or cheek flap. (Joseph) (The objection to this procedure is the proneness of the lining flap to undergo necrosis, due to torsion on its pedicle.)

INFLAMMATORY AND NEOPLASTIC DISEASES OF NOSE

RHINOPHYMA (WHISKEY NOSE, NODULAR NOSE, ELEPHANTIASIS OF NOSE, CYSTADENOFIBROMA OF NOSE)

The term "rhinophyma" was coined by Hebra (100) in 1856 but the condition was known to the early Arabians and had been described by Hippocrates. The disease is essentially a progressive benign hypertrophy of the lower half of the nose, affecting the connective tissue, sebaceous glands blood vessels, and fatty tissue. The cause is unknown. It is more common in men in the proportion of 12 to 1, appearing usually in middle and later life. It has been attributed to gastro-intestinal disturbances and to alcoholism, but, contrary to public opinion, the addiction to alcohol probably bears no causal relationship to the condition. Haurahan believes it to be a chronic inflam matory reaction produced by the accumulation of large quantities of sebum in the dilated glands.

Pathologically, rhinophyma is considered to be the final stage of acne rosacea. Early in the disease there is a dilatation of the blood vessels with a resultant increase in the blood supply causing an overproduction of connective tissue, which in time forms lobulated masses ranging in size from a pea to a cherry and separated from one another by dense fibrous septa. The nodules are soft in consistency and have a shiny, flat appearance varying in color from a dull red to a purplish gray The skin is thickened and shows telangiectatic blood vessels The orifices of the sebaceous glands are enlarged, patulous, and filled with sebaceous material.

The disease develops slowly over a period of 5 to 20 years. It is easily recognized by the characteristic color of the mass, the dilated, threadlike, tortuous blood vessels in the regions of the alae and nasolabial folds, and by the multilobular tumors pitted with the openings of large sebaceous glands which pour out an oily secretion on the surface and give the nose a greasy appearance

Treatment. Many forms of treatment, both non-surgical and surgical, have been suggested, but unfortunately none has been found entirely satisfactory. X-ray and

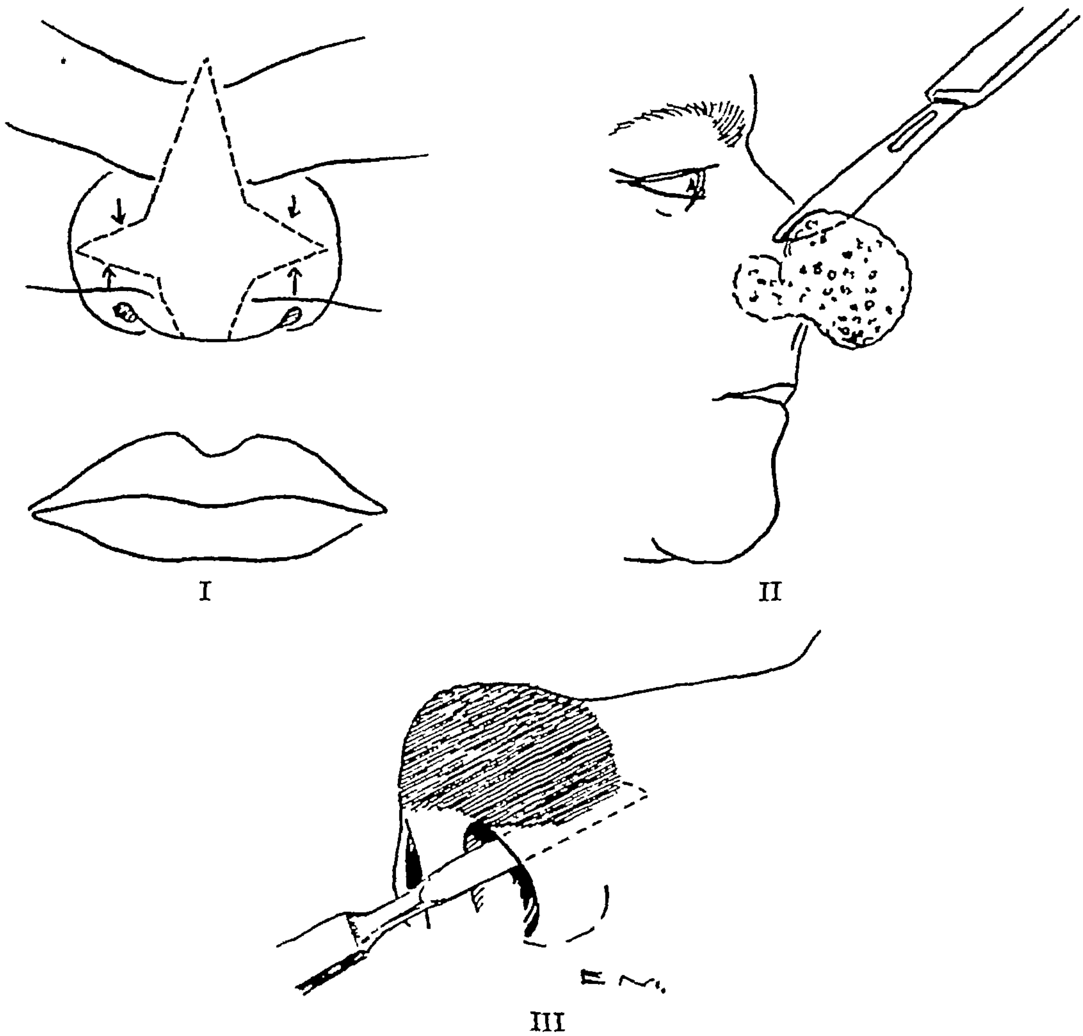


FIG 453 Operations for rhinophyma *I*, pathologic tissue removed in form of cross-shaped excision, and margins of wound approximated (Dieffenbach) *II*, diseased tissue shaved down to cartilaginous base and allowed to heal by granulation (von Langenbeck) *III*, hypertrophied tissue excised subcutaneously through intranasal incision

radium therapy are of little service after the condition is once fully developed, although in the incipient stage graduated doses may check the progress of the disease Caustics are unreliable, because the extent of the necrosis which follows their application cannot be previously determined.

Attempts to relieve the condition by surgical measures date back to 1845, when Dieffenbach (45) reported the removal of the pathologic tissue in the form of a cross-shaped excision (fig 453) Von Langenbeck (1851) excised the soft tissue down to a cartilaginous base and permitted the surface to heal by granulation Gersuny (69,

70) extirpated the mass and covered the raw area with a graft. Stromeyer (302) (1864) excised the growth, leaving the fundi of the sebaceous glands intact to serve as a nidus for epithelization, and this procedure was repeated by Sick (291) in 1905 Ollier and Trendelenburg (1876) decorticated the degenerated tissue and applied a 50 per cent resorcin paste to the wound.

The treatment which has met with greatest success is the following In mild cases involving little thickening the hyperplastic tissue is excised intranasally, thus An incision is made in the vestibule along the anterior margins of the nostrils. The skin is separated from the subjacent tissue with a sharp knife and the connective tissue, blood vessels, and hypertrophied glands are excised subcutaneously down to the cartilage The nostrils are then packed with xeroform gauze, and drainage is instituted for 24 hours.

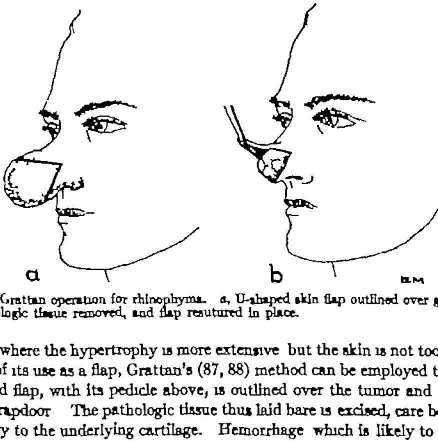


FIG. 454. Grattan operation for rhinophyma. a, U-shaped skin flap outlined over growth. b flap raised, pathologic tissue removed, and flap resutured in place.

In cases where the hypertrophy is more extensive but the skin is not too degenerated to permit of its use as a flap, Grattan's (87, 88) method can be employed to advantage A U-shaped flap, with its pedicle above, is outlined over the tumor and raised in the form of a trapdoor The pathologic tissue thus laid bare is excised, care being taken to avoid injury to the underlying cartilage. Hemorrhage which is likely to be extensive, is controlled by pressure with hot compresses. After the removal of the diseased tissue, the flap is sutured back in place. Healing is usually complete in 10 days. Post operatively two x-ray treatments of a suberythemal dose are given one week apart. Any remaining scars are smoothed down with 50 per cent trichloracetic acid (fig 454)

In those cases in which the skin is too degenerated to be used as a flap, decortication produces the most satisfactory results. The procedure follows With the left index finger held inside the nostril as a precaution against injury to the cartilage, the growth is split through the middle with a razor It is then shaved down until the nose is reduced to its normal proportions It is necessary to leave a rim of untouched skin around the nares, otherwise disfigurement will result from the secondary contraction During the excision care must be taken to avoid injury to the cartilage and to preserve enough islands of epithelial cells for subsequent epithelization The raw area is

covered with several layers of xeroform gauze overlaid with dry gauze, and a stent mold is applied to keep the dressing in place The dressing is removed when the surface has healed over—a process requiring 7 to 10 days. If granulations are exuberant, they may be reduced by x-ray applications

Andrews (2) destroys the tumor by dessicating it or by shaving it off with a cutting current, using either a needle or a flattened loop The superficial slough separates and leaves a sterile granulating surface which in time becomes covered with epithelium

Syphilis of Nose

Deformities of the nose resulting from syphilis are of frequent occurrence Statistics indicate that 25 per cent of all luetic patients show some degree of nasal destruction. The inflammation begins in the nasal mucous membrane as a mucous patch and spreads to the cartilages and bones Eventually gummata form, which in time undergo necrosis and ulceration, the subsequent cicatrization resulting in a characteristic disfigurement Clinically, there is an offensive discharge containing fragments of necrotic tissue and sequestra

Since the cartilaginous septum is the first part to be affected, the earliest symptom is the appearance of a dorsal depression just above the tip of the nose resembling the deformity resulting from a faulty submucous resection The vomer, nasal bones, and frontal processes of the superior maxillae in the order mentioned are the next structures to be attacked, and with their destruction the typical syphilitic saddle-nose is produced The bridge sinks to the level of the zygomatic arches, and the tip and alae take a backward position, drawing the vestibules and nasolabial folds upward The overlying skin is glossy and anemic and covered with pearly white blotches In time the skin is likewise destroyed, the nose appearing as an aperture on the face, with more or less conservation about the alae

Treatment Before the correction of a syphilitic nasal deformity is undertaken, every means, both general and specific, must be employed for the relief of the causal factor The manner of reconstructing the loss follows the principles laid down for rhinoplasty as a whole—i e , the lost structures, whether skin, mucous membrane, supporting structure, or all three, must be replaced if a satisfactory result is to be expected

When the deformity involves a loss of cartilaginous support, but the skin and mucous membrane remain intact, correction may be achieved by the subcutaneous implantation of a properly shaped piece of cartilage (p 700) Should the lining be destroyed, it can best be restored by Gillies' (72) method (fig 455). Prior to operation a splint is constructed composed of a tray designed to hold modeling compound, and an adjustable upright to be attached to cap-splints fastened to the upper teeth An incision is made along the upper gingivolabial sulcus extending from one canine tooth to the other The soft tissues are separated from the maxillae around the pyriform opening and over the osseous dorsum, the dissection being continued until the soft parts assume their normal relations A piece of sterilized softened stent is then forced into the nasal cavity, and by external digital manipulation it is molded to reproduce the desired shape of the nose The tray attached to the upright is then heated and pressed into the compound When the mold has hardened, it is removed (on the tray) and covered with a thin razor graft, raw side out, taken from a non-hairy portion of the body, such as the forearm or inner side of the thigh, the graft having been cut in one piece, so that it will entirely

cover the mold The raw area on the inside of the nose is cleansed of all blood-clots, and the upright carrying the graft-covered stent is reinserted and attached to the cap-splints previously fastened to the teeth Kilner's splint is often found convenient (fig 456)

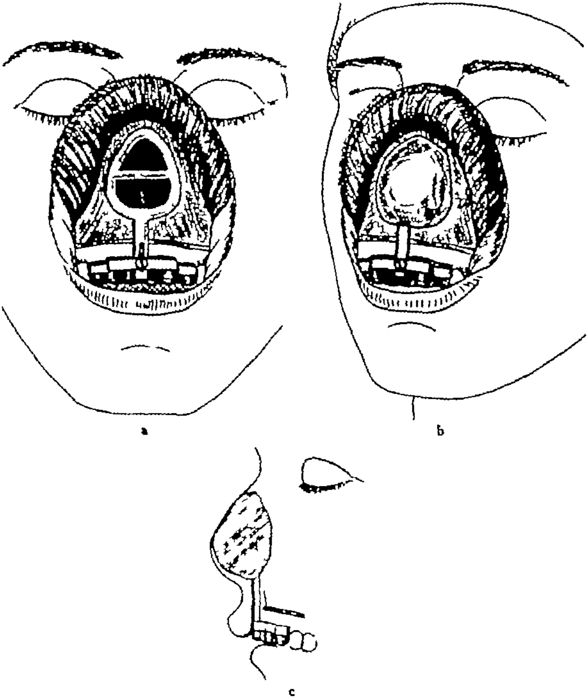


FIG. 455 Gillies method for restoration of nasal lining following syphilis. *a* soft tissues separated from maxillae and nose through incision in gingivolabial sulcus. Scar tissue removed. Splint, designed to hold modeling compound attached to teeth *b* graft-covered mold in place. *c*, sectional view For details, see text.

After 10 days the mold is removed and the inside of the nose will be found epithelized. The mold is cleansed and replaced for another 10 days, after which it is supplanted by one of gutta-percha, which is worn until all tendency to contraction has ceased—a period averaging 2 to 3 months—being removed daily for cleansing At a later stage

the margins of the oronasal communication are pared and united, and a cartilage implant is introduced to furnish support

Kazanjian (137) replaces the lining by turning in two flaps of skin from the upper lip, as follows (fig 457) "An incision is made around the alae margins extending through the base of the columella The skin is freed from the fibrous adhesions and is dissected freely over the whole nose, including the region of the nasal bones A flap is prepared on each side by a curved incision beginning from the side of the ala in a

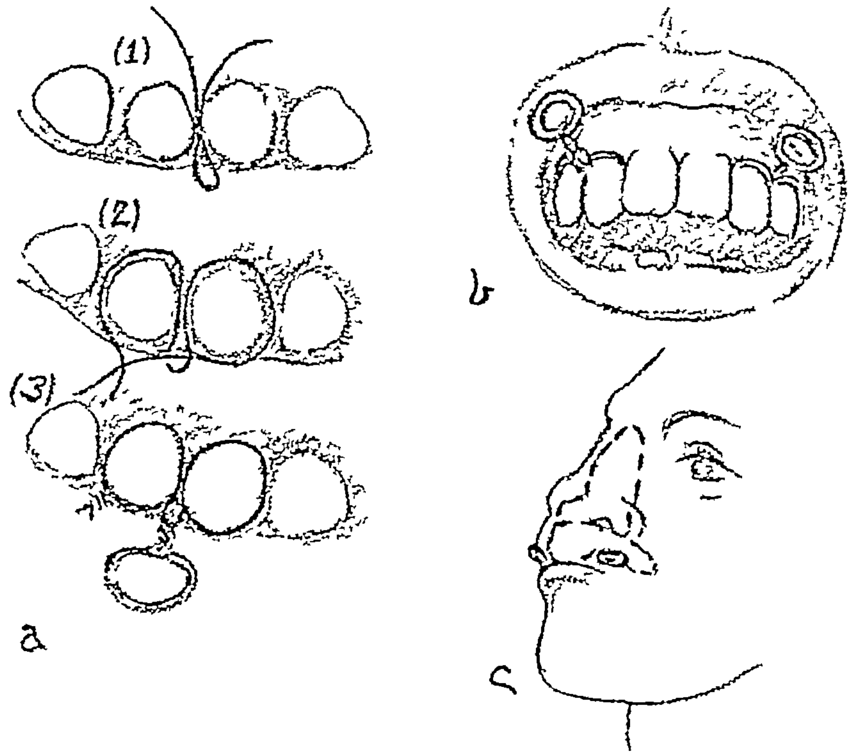


FIG 456 Kilner's splint for holding graft-covered mold in place *a*, method of attaching wire rings to teeth *b*, rings in place *c*, graft-covered mold supported on wire rings

FIG 457 Kazanjian's method of replacing lining by use of rotation flaps taken from upper lip *a*, incision made around alar margins, extending through base of columella Flaps outlined *b*, flaps raised, rotated inward, and sutured in place, to form lining Secondary wound closed *c*, pedicles cut Alae sutured into position For details, see text

direction corresponding with the lines of the upper lip These flaps are dissected and turned inward, and sutured in place to form a new lining for the nasal cavity. No attempt is made to suture the base of the wings of the nose at this stage. This is left free, as shown in the diagram In a later operation, the lower parts of these flaps, which are forming the inner lining of the nose, are cut through, some of the excess tissue is excised and the base of the alae are sutured in position"

When cover, lining, and support have been destroyed, the problem is one of partial or complete rhinoplasty

Lupus of Nose

Nasal lupus involves primarily the cartilaginous septum and the skin of the vestibule. The course of the disease is slow, extending over a period of many years. Eventually, it may destroy the entire nose. The lesion first appears as a group of slightly raised, translucent, brownish-pink, apple-jellylike nodules, deeply embedded in the corium and cartilage. The nodules in time undergo ulceration, and are replaced by a new collection on the margins of the lesion As the ulcer spreads peripherally, the center undergoes cicatrization, the scar being thin and avascular In the later stages the nostrils become stenosed, and the lobule is drawn up the nose presenting a characteristic shrunken, pointed, scarred appearance, resembling a parrot's beak. The causative agent is the tubercle bacillus which probably gains entrance through direct inoculation. The condition usually appears in early life, and women are particularly predisposed

Treatment The constitutional management is a medical problem and follows the general rules laid down for the treatment of tuberculosis in other parts of the body Locally, Finsen light is effective, the area being devascularized by pressure with the quartz. But this treatment is prolonged and tedious, and for this reason destruction of the affected area by excision and cauterization is preferable. X ray therapy is dangerous because of its destructive effect on cartilage and the danger of epitheliomatous degeneration

After the infection has been controlled, the reconstruction is carried out in the manner discussed in the section dealing with partial rhinoplasty

Neoplasms of Nose

Benign

Benign neoplasms of the nose are relatively uncommon and present the same characteristics as similar tumors in other parts of the body Those most frequently encountered are (1) Papillomata. These growths usually originate in the vestibule, and can easily be removed with a snare. The raw surface which remains is destroyed with an electrocautery as a precaution against recurrence. (2) Osteomata. These tumors commonly spring from the nasal bones. They are as a rule pedunculated and cause no pain. They grow slowly but progressively and in time may become so large as to obstruct nasal respiration and cause marked deformity Their removal is accomplished by raising the soft parts over the tumor through either an external or an internal incision and chiseling the growth thus exposed down to a normal contour Recurrence is uncommon (3) Angiomata. These growths are described in Chapter XIX. Rarer forms of benign nasal tumors include chondromata, osteochondromata, fibromata, adenomata, lipomata, gliomata, and mixed tumors.

Malignant

Malignant tumors of the nose although rare, are more common than the benign forms. It is estimated that 60 per cent are carcinomata 30 per cent sarcomata, and

10 per cent, endotheliomata (129) Of the sarcomata Hellner distinguishes (1) an osteogenetic type arising from bone-forming germinal tissue, the cells being of the spindle- or round-cell variety, (2) Ewing's sarcoma which presents the picture of an alveolar sarcoma, and (3) a mixed type containing chondromatous and myxomatous tissue As elsewhere in the body, the malignancy is measured by the degree of failure on the part of the cells to become differentiated. Thus, the round and spindle-cell varieties are more malignant than the fibrosarcomata, chondrosarcomata, and myxosarcomata (p. 1333)

Carcinomata of the external nose rarely occur as primary growths, they are usually secondary to carcinoma of the cheek, antrum, or tonsils The squamous cell type is the one most commonly encountered in this locality, and, like cancer elsewhere, is more malignant than the basal-cell variety The tumor may exist for some time without giving rise to definite symptoms Gradually the patient begins to complain of obstruction to respiration, intermittent epistaxis, foul discharge, and pain The general manifestations are often misleading The usual evidences of malignancy, such as cachexia and anemia, may be entirely absent The lymphatic glands are not involved until the disease is well advanced The local features will depend upon the location and spread of the tumor When it arises from the anterior aspect of the bone, the first manifestation is a subcutaneous swelling, eventually the overlying skin is invaded If the growth spreads upward, the lids become swollen, the eyeball is displaced, vision is interfered with, and epiphora develops from compression of the nasal duct If it spreads laterally, the antrum is attacked (p 996) A downward growth destroys the alveolar process and palate and may cause perforation into the mouth If the tumor extends backward, it occludes the pharynx and results in dysphagia, it may press upon the external carotid artery and lead to its erosion and hemorrhage, or it may even penetrate the base of the skull The diagnosis can be made by x-ray examination, transillumination, and exploratory incisions followed by a biopsy

As to the operability of these malignant growths, no inflexible rule can be laid down. Every case must be decided separately Those most amenable to surgery are the slow-growing tumors which are hard, well defined, limited to the nose, and without skin involvement

Treatment Simple surgical excision is possible only in those exceptional cases in which the growth is circumscribed In more extensive growths the use of the knife has been supplanted by diathermy, despite the fact that the latter method entails technical difficulties, and leads to delayed healing as well as an increased tendency to secondary hemorrhage Experience has shown that the best results are obtained by preoperative administration of radiotherapy, removal of the tumor by endothermy, and postoperative recourse to x-ray and radium

Three or 4 days prior to operation the patient receives radiotherapy, to lower the viability of the tumor cells and bring about a regression in the size of the swelling The method of administration and the proper dosage are discussed on page 997

The operation is best performed under endotracheal anesthesia, although it may be carried out under local anesthesia by blocking the fifth nerve at the gasserian ganglion It is essential that the growth be removed at one sitting, to obviate the danger of dissemination. The old classical incisions for the exposure of the tumor have been abandoned The intranasal approach is inadequate. Rouge's method occasions con-

siderable bleeding, while the space gained is slight. The latter method consists in detaching the mask of the face from the maxilla by an incision in the upper gingival sulcus. The soft parts are retracted, the septum is divided, and the nasal cartilages are completely separated, so that the nasal fossae are laid bare.

Moure's (214) lateral rhinotomy, as a rule, is a satisfactory approach for the removal of the growth. The incision is begun in the inner third of the eyebrow, carried down the side of the nose, around the ala nasi, and through the midline of the upper lip.

If a wider exposure is necessary, the incision suggested by Trotter (313) furnishes an excellent approach (fig. 621-b). It is carried from the inner canthus along the side of the nose, around the ala, and through the center of the upper lip. The lower lid is then turned down, and, on its inner surface a horizontal incision is directed from the starting point of the original incision and carried across the palpebral conjunctiva to the outer canthus, ending opposite the malar eminence. Through this incision the soft tissues on the side of the nose are detached with an elevator and retracted toward the median line, the tissues of the cheek are then raised and drawn downward and outward. Thus free access is given to the osseous dorsum, the frontal process of the superior maxilla, and the canine fossa. Bleeding is profuse but can usually be controlled by pressure. With the lacrimal sac held out of the way, the frontal process of the maxilla is cut through with a chisel on a line extending from the pyriform opening to the lower margin of the orbit, the division being made medial to the infra-orbital foramen. Another cut is made through the internasal articulation and carried outward to the supra-orbital margins. The piece of bone thus outlined is twisted out of its bed with a pair of stout forceps. The growth now exposed is destroyed by diathermy with 2 olive shaped electrodes, being "cooked" until it assumes a grayish appearance. The surface is then curetted, and the process is repeated. Finally, the area is treated with a high tension current until a crust is formed to protect the wound against infection. The cavity is packed loosely with gauze, the end of the strip being allowed to project from the nostril. Radium tubes are inserted with the packing, the dose ranging from 500 to 2000 mg. hours. The method of application is described on page 1004.

Another good exposure is obtained by elevating the upper lip and opening the antrum through the canine fossa, and then removing the lateral wall of the nose, as in Denker's (41) operation. The remaining deformity is obliterated by means of a removable obturator carried on a denture.

After the excision of the tumor the deformity will be more or less marked, and the question of surgical rehabilitation arises. Unfortunately, the majority of these cases do not offer good prospects for reconstruction, owing to the tendency on the part of the growth to recur and the poor quality of the irradiated tissues.

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CHAPTER XII

THE EYELIDS

ANATOMIC CONSIDERATIONS

The eyelids are movable musculomembranous folds located in front of the eyeball They merge with the eyebrows above and with the cheeks below By their closure they exclude foreign bodies and light and by their winking mechanism they moisten the eye and aid in the removal of injurious particles When the lids are closed, the margins fall into accurate apposition, and with the aid of the oily secretion from the meibomian glands the closure is made water-tight Failure of this function explains the desiccation and ulceration of the cornea characteristic of lagophthalmos The transverse opening between the lid margins forms the palpebral fissure, its lateral or temporal extremity terminating in an acute angle known as the lateral or outer canthus, and its medial or nasal end in a rounded angle called the medial or inner canthus, which shows an elevation designated the caruncle The shape and width of the fissure, rather than the actual size of the eyeball, is what objectively determines the size of the eye Jameson (45) points out that when the eyes are looking straight forward, the margin of the upper lid is on a line between the pupillary margin and upper limbus A drooping of the lid below this line indicates ptosis The vertical measurement of the palpebral opening is normally 9 mm and the horizontal, 27 mm A reduction in these figures may indicate the necessity of a canthotomy The distance between the border of the lid and the arch of the eyebrow ranges from 15 to 18 mm, and the vertical distance from the lid border to the superior arch of the tarsus is 8 mm The margin of the lid presents an anterior rounded ridge from which springs a row of curved cilia, the eyelashes, and a posterior ridge which is sharp and in close contact with the eyeball and shows the openings of the meibomian glands The surface between the two ridges appears as a dark line and is called the intermarginal space, or "gray line," an important surgical landmark An incision along this line divides the lid into an anterior lamina comprising skin and cilia, subcutaneous tissue, and orbicularis muscle, and a posterior lamina consisting of the tarsus, meibomian glands, and conjunctiva (fig 459)

From within outward the lids are composed of 5 layers (fig 458), as follows: (1) *Cutaneous Layer* The skin over the eyelid is the thinnest in the body, contains no fat, and except along the lid margin is loosely attached to the subjacent tissue The lax adherence permits of the wrinkling and stretching of the skin on opening and closing of the lids When the eye is open, the lids are thrown into many transverse folds In the upper lid one of the folds is deeper than the others and divides the lid into two parts, the upper being in relation to the orbit and the lower in relation to the eyeball Whenever possible, incisions are made to follow the direction of these folds, so that there may be a minimum of scarring Because of the laxity of the eyelid

skin, it lends itself readily to reconstructive operations, but for the same reason it is easily distorted by the contraction of scar tissue. (2) *Subcutaneous Layer* The subcutaneous tissue is lax and is peculiar in that it contains no fat. Its loose arrangement of connective tissue permits of great distention in the presence of exudative and transudative fluids. Such effusions, however, rarely pass from one lid to the other because of the firm attachment of the skin to its underlying structures at the commissure, *nor is it often transferred into the orbit because of the strong fascial sheath.* This explains why inflammations of the eyelid are so rarely complicated by orbital

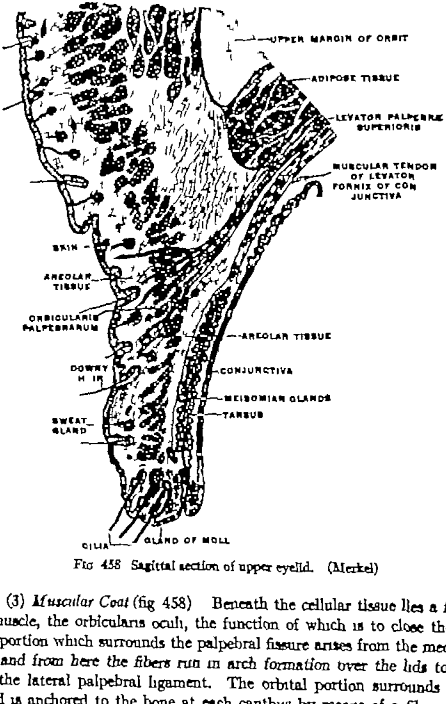


FIG 458 Sagittal section of upper eyelid. (Merkel)

cellulitis. (3) *Muscular Coat* (fig 458) Beneath the cellular tissue lies a flat circular band of muscle, the orbicularis oculi, the function of which is to close the lid. The palpebral portion which surrounds the palpebral fissure arises from the medial canthal ligament, *and from here the fibers run in arch formation over the lids to meet in a* raphé at the lateral palpebral ligament. The orbital portion surrounds the orbital cavity and is anchored to the bone at each canthus by means of a fibrous band. A few fibers run along the posterior lip of the lid margin (*Riolan's muscle*) *In ordinary* approximation only this last-mentioned muscle contracts, but in forced closure the

whole orbicularis oculi takes part, its action spreading from the outer to the inner canthus in a wavelike motion The *levator palpebrae superioris muscle*, the elevator of the lid, arises from the bone immediately around the optic foramen, proceeds into the orbit over the superior rectus to which it is attached by a fascial band, and is inserted into the orbicularis oculi, the tarsus, and the skin at the fornix Its attachment at the latter point causes the eyelid skin to be drawn in between the eyeball and the orbital margin on raising the lid The lids also contain smooth muscles known as Mueller's, or the superior and inferior tarsal muscles They originate around the fornix and are inserted into the edge of the tarsus (4) *Tarsal Coat* The tarsus is a dense plate of connective tissue which forms the supporting structure of the lids In the upper lid it is several millimeters wider than in the lower The two plates are connected with the lateral orbital walls by means of the tarsal ligament and with the upper and lower margins of the orbit by means of the tarso-orbital fascia Each

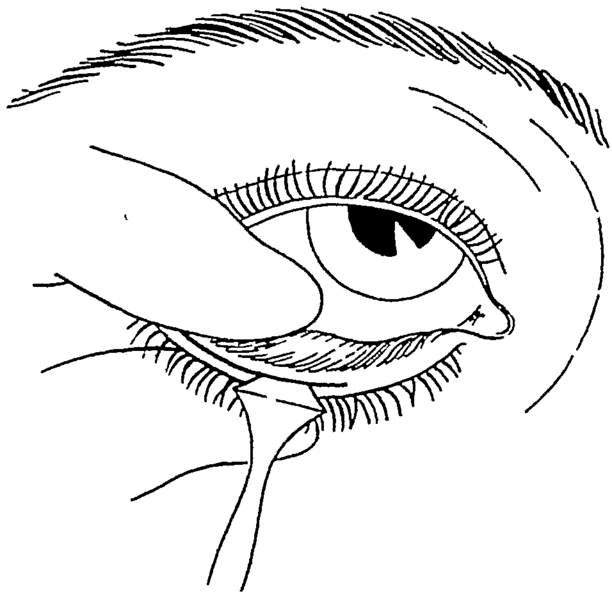


FIG 459 Intermarginal incision along "gray line" divides lid into anterior lamina composed of skin, subcutaneous tissue, and orbicularis oculi muscle, and posterior lamina comprising tarsus and conjunctiva

plate shows an upper convex border, a lower concave border, and an anterior convex and posterior concave surface Within the substance of the tarsus in parallel rows are 30 to 40 meibomian glands which open on the free margin of the lid On its anterior surface lie the fibers of the orbicularis muscle, and its posterior surface is covered with the conjunctiva. (5) *Mucous Coat* On the under surface of the tarsus and closely attached to it is the conjunctiva The membrane is reflected over the eyeball, the fold of reflection forming the fornix, which lies in lax horizontal folds to permit of free movement of the eye

The *arteries* supplying the inner part of the lids are the palpebral branches of the ophthalmic, and those that supply the outer part are branches of the lacrimal and transverse facial They run in the loose tissue along the free margins of the lids between the orbicularis muscle and the orbital septum, passing from the medial toward the lateral canthus The *veins* are numerous and wide and empty into the ophthalmic and facial veins They pass through the orbicularis muscle, hence, a spasm of the

muscle, by compressing the veins, may result in edema. The *lymphatics* of the eyelids form a pretarsal and retrotarsal network which drains into the preauricular and parotid lymph-nodes. The *motor nerve* supplying the orbicularis oculi muscle is the facial, and that supplying the levator palpebrae is the oculomotor. Sensory innervation is derived from the trigeminal through its ophthalmic and maxillary divisions. The involuntary palpebral muscles are activated by the sympathetic nerves.

WOUNDS OF EYELID

Wounds of the eyelids range in severity from an insignificant laceration to complete destruction with or without injury to the eyeball or bony orbit. They are of special significance because of the danger of injury to related structures. The causative factors are the same as those responsible for traumatisms elsewhere in the body, some of the most common being flying glass from windshields broken in automobile accidents, powder and gasoline explosions, scattering steel particles in mechanical and timber industries and acid and alkali burns received in battery and plating factories.

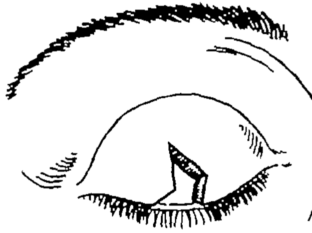


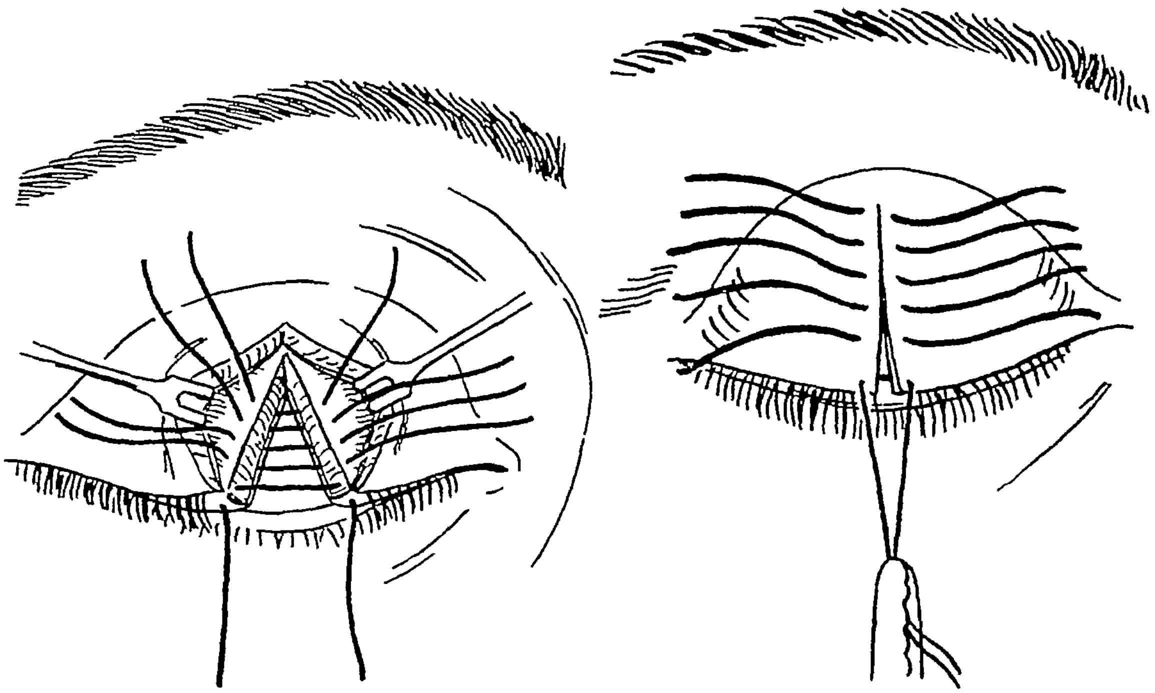
FIG. 460. Method of trimming eyelid wound, to compensate for subsequent contraction and notching at suture line. (Mirault D Angus)

The management of these injuries is governed by the rules which apply to other traumatisms about the face (p. 265). The direction assumed by the wound is important. If it lies horizontally across the lid, there will be little gaping and the resultant cicatrix will be insignificant. But if it divides the muscle fibers vertically, great distortion of the lid and displacement of the eyelashes are apt to accompany healing and if the nerve fibers have been severed, paralysis may ensue.

In wounds of the eyelids hemorrhage is rarely serious and can be controlled by pressure. To allay spasm of the lids and relieve pain a few drops of a 4 or 5 *per cent* solution of cocain are instilled into the conjunctival sac. The area is cleansed as thoroughly as possible by irrigation with boric acid, a mild bicarbonate, or a normal salt solution. Foreign bodies and pigment from road dirt are removed by scrubbing, hematomata are evacuated and any embedded particles are removed with a fine knife or corneal trephine. If the wound communicates with the nose or with a fracture extending into the ethmoidal sinuses, the lids may become so distended with gas as to cause pressure on the eyeball. In such cases a number of punctures are made to permit of the escape of the air. Débridement should be done sparingly, every frag

ment of viable skin and soft tissue being preserved Lacerated wounds are trimmed to form straight lines In the case of full thickness injuries the cut edges of the tarsal plate are shaped evenly and their lengths equalized, in order that accurate closure may be facilitated When possible the wound margins are made to assume the form of a triangle, with its base on the palpebral margin To prevent notching at the lid margin on contraction of the suture line, the lower part of the wound may be trimmed to form a flap, as illustrated in Figure 460

The method of closure will depend upon the amount of tissue lost Direct approximation of the wound margins is possible when as much as $\frac{1}{3}$ of the total eyelid or any one of its coats has been destroyed Careful suturing will do much to obviate deformities In wounds extending into the lid margin the first stitch is passed through the margin, incorporating a good bite of the tarsus, and is tied in such a manner that



a b

FIG 461 Closure of eyelid wound in layers *a*, first suture passed through tarsus and left long, to be used as tractor and facilitate passage of subsequent sutures Tarsus sutured with #000 catgut *b*, skin sutured with fine silk

the lid margin and cilia line of both sides will fall into their normal relations The ends of the suture are left long and used as a tractor to facilitate the passage of the balance of the sutures The cut structures are united in layers from within outward, the conjunctiva and the tarsal plate being sutured with #000 catgut and the skin edges coapted with a subcuticular suture of fine silk (fig 461) The skin sutures should be so planned that they will not coincide with or overlap those previously placed in the conjunctiva and tarsus This purpose may best be accomplished by recourse to Wheeler's (81) "halving method" (fig 462). In this procedure, in place of the mere edge-to-edge apposition of the wound margins, the thickness of the lids is divided and the edges overlapped and secured to each other in the manner employed by carpenters A rectangular flap of skin, with its free edge lying on the margin of the wound, is raised If the wound is near the outer canthus, the flap is made to lie on

the nasal side of the lid, and if the lesion is located nearer the medial canthus, the flap is raised on the opposite side. On the side of the wound opposite the flap an area of the same dimensions as the flap is denuded down to the tarsal plate A silk mattress-suture is then passed from the denuded area on one side through the base of the skin flap on the other When the ends are tightened, the flap is automatically drawn into the bed prepared for it. The stitches are tied over small rubber plates. The remaining skin margins are united with fine silk sutures.

Following closure a layer of sterile vaselin combined with 1 3000 bichlorid of mercury is introduced into the conjunctival sac to prevent irritation of the cornea by the sutures. Because of the good blood supply, drainage is usually unnecessary, but in the case

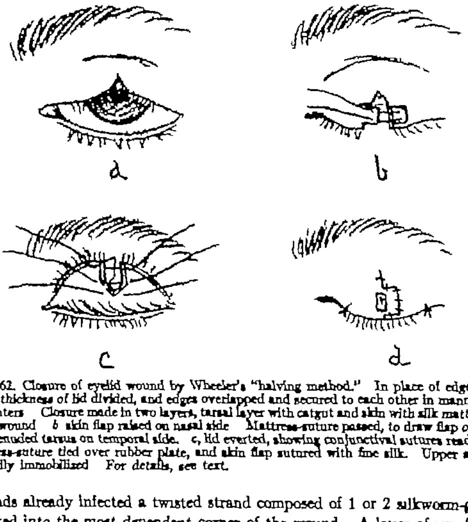


FIG 462. Closure of eyelid wound by Wheeler's "halving method." In place of edge to-edge apposition, thickness of lid divided, and edges overlapped and secured to each other in manner employed by carpenters Closure made in two layers, tarsal layer with catgut and skin with silk mattress-sutures a, eyelid wound b skin flap raised on nasal side Mattress-suture passed, to draw flap over prepared area in denuded tarsus on temporal side. c, lid everted, showing conjunctival sutures ready to be tied. d, mattress-suture tied over rubber plate, and skin flap sutured with fine silk. Upper and lower lid temporarily immobilized For details, see text.

of wounds already infected a twisted strand composed of 1 or 2 silkworm-gut sutures is inserted into the most dependent corner of the wound A layer of xeroform gauze is placed directly over the suture line, and this is covered with a layer of dry gauze on which is superimposed a thick cotton pad held in place by means of several narrow strips of water proof zinc oxid adhesive plaster Dressings should not be permitted to become saturated with blood or secretions, lest they become heavy and irritating Sutures, especially those passed through the conjunctiva, should not be left in place longer than 4 or 5 days.

Fractures of Orbital Framework Wounds of the eyelid are frequently complicated by fractures of the orbit, owing to the extreme thinness of the bone, and such fractures are always serious, because of the proximity of important structures. Fractures of

the orbital roof may damage the meninges and brain, those of the floor may involve the infra-orbital nerve, ocular muscles, and maxillary sinus, those of the inner wall may penetrate the nasal fossa, allowing an escape of air into the orbit which may be so extensive as to bring about exophthalmos, and finally, those of the apex may encroach upon the cranial nerves and lead to blindness or ophthalmoplegia Obviously, the symptoms will depend upon the site of the fracture (p 960)

The management of orbital fractures in general follows the same plan as that outlined for fractures of other bones of the face and skull Fractures of the floor are discussed in connection with those of the maxillofacial compound (p 970) In the case of depressed fractures about the orbital roof an incision is made along the supra-orbital arch just below the eyebrow, the flap is turned down, and the eyeball gently depressed to expose the bone Foreign bodies and all small unattached bits of bone are removed, but complete débridement of the fractured bone is to be avoided in this region, as it may result in a loss of support for the frontal lobe of the brain All depressed fragments are elevated The pachymeninx, which in this area is tightly adherent and thin, is apt to be torn, and if this be the case, it should be repaired so as to prevent the escape of cerebrospinal fluid and the entrance of air into the cranial cavity from the frontal sinus The wound is closed with or without drainage, depending upon the conditions found (p 964)

RECONSTRUCTION OF EYELID

The preliminary preparation for operations on the eyelid is essentially the same as for any surgical procedure (p 485). Since these operations are usually not in the nature of an emergency, there is sufficient time for an optimal improvement of the patient's body chemistry All sources of infection in the lacrimal apparatus, conjunctiva, teeth, tonsils, and sinuses are eliminated. Cultures and smears of the lacrimal and conjunctival secretions are made for the detection of virulent organisms On the evening before operation the general routine measures are carried out. The eyelashes are clipped short, the eyebrows shaved, and the parts scrubbed with green soap and water Several drops of 10 per cent argyrol are introduced into the conjunctival sac, after which it is irrigated with a saturated solution of boric acid A sterile gauze pad is then placed over the eye and held in place by means of adhesive tape An hour before the patient enters the operating room a sedative is administered to allay apprehension (p 486) Then, at 5-minute intervals, several drops of a 1 per cent solution of butyn are instilled into the affected eye Immediately before the operation a drop or two of sterile castor oil is introduced into the conjunctival sac, and the face is scrubbed with green soap and water, special attention being given to the skin around the eye and eyebrow Following the scrubbing the skin is swabbed with ether and finally with alcohol The eye is then draped with a sheet about 90 cm square, with an oval opening 8 cm in length

Anesthesia The majority of eyelid operations can be performed under local infiltration and blocking of the supra-orbital and infra-orbital nerves The needle is inserted at the lateral canthus and carried to the medial canthus, and a 1 to 2 per cent solution of procain, containing 10 drops of epinephrin to the ounce, is injected as the needle is withdrawn (fig 463) Only enough of the solution is used for the production of anesthesia, as an excessive quantity is apt to distort the anatomy. If general anesthesia is required, the endotracheal method of administration is the one of choice

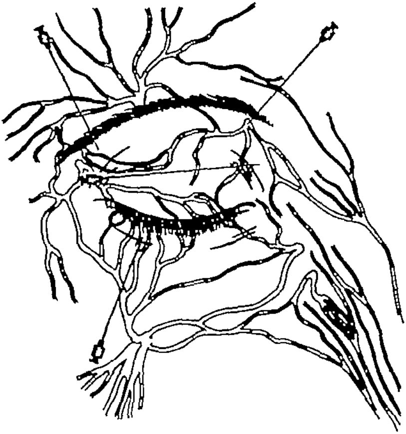


FIG 463 Local anesthetization of eyelid. Upper left needle blocking frontal nerve, upper right blocking lacrimal, central blocking infratrochlear and lower blocking infra-orbital.

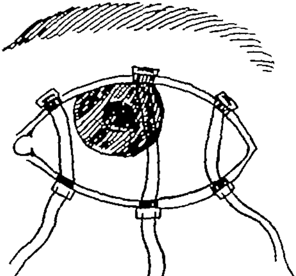


FIG. 464 Immobilization of eyelids by temporary tarsorrhaphy Inner borders of both lids denuded at 3 corresponding points and united by mattress sutures passed through rubber plates For details see text. (Wheeler)

Immobilization of Lids In operative procedures on the eyelids requiring post operative immobilization a temporary tarsorrhaphy is performed prior to operation For purposes of prolonged fixation the inner borders of the apposing lid margins are

denuded for a distance of 4 to 6 mm at three points—one medial to the outer canthus, one on the temporal side of the center of the lids, and the other halfway between the center of the lids and the inner canthus—the pupillary area thus being left free (fig 464) The needle is carried through the skin of the lower lid at a point 2 or 3 mm from its margin and is brought out through the denuded area From here it is made to pass through the corresponding raw area in the upper lid margin and to emerge through the skin of the upper lid at a like distance from its margin It is then reinserted a few millimeters from its point of exit, brought out through the denuded area, carried through the denuded area in the lower lid, and made to emerge at a point a few millimeters distant from its point of entrance Sutures are passed through the remaining denuded areas in a similar manner The ends of the 3 sutures protruding through the lower lid are tied over small rubber plates The stitches are removed at the time of the first dressing 5 days later The adhesions are not liberated until the full benefits

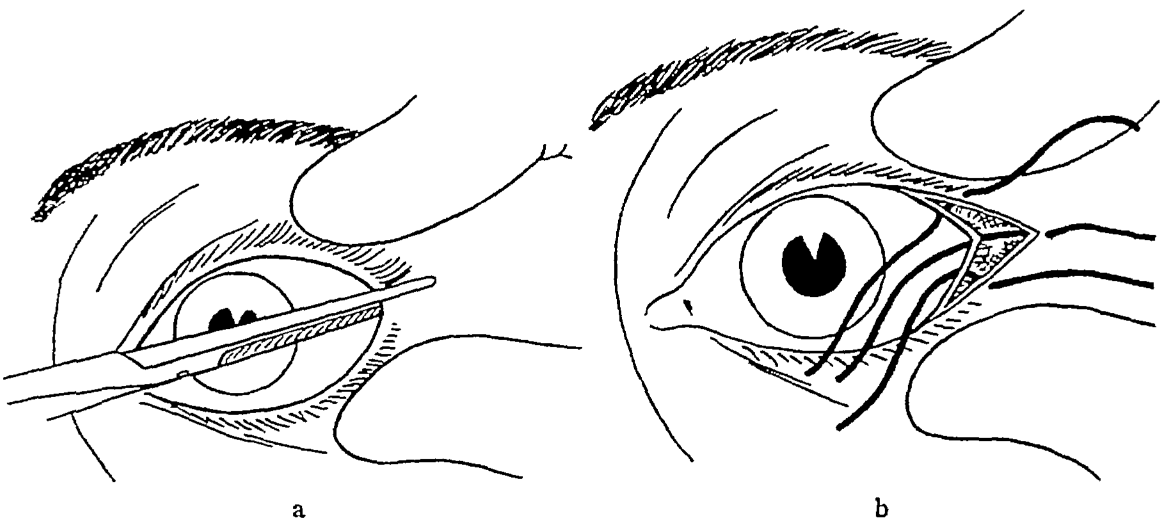


FIG 465 Elongation of palpebral fissure by canthotomy *a*, lateral canthal ligament put on stretch With one limb of scissors in commissural sac and other on skin, canthus divided horizontally *b*, rhomboidal wound closed by uniting skin to conjunctiva First suture passed at angle of wound

of the reconstruction have been obtained, a period usually of about 6 to 8 weeks or longer When immobilization is no longer necessary, the adhesions are divided with a sharp scalpel, and the raw areas are touched with silver nitrate For a shorter immobilization the sutures are passed in like manner but without denudation of the margins. If only the upper lid requires fixation, 2 or 3 mattress-sutures are passed through its margins and fastened to the cheek by means of adhesive tape, in the case of the lower lid the stitches are passed similarly but are attached to the forehead

Enlargement of Palpebral Fissure In order to gain free access to the structures within the orbital cavity—for example, for the purpose of relining a contracted socket—it is sometimes necessary to elongate the palpebral fissure temporarily by a canthotomy (fig 465) The procedure is as follows: The two lids are separated and drawn toward the nose by the thumb and forefinger of the left hand, the external canthal ligament being thus put on stretch The blunt end of a pair of straight scissors is then inserted deeply into the commissural sac beneath the outer canthus, and with one cut the tissues between the blades are divided in a horizontal direction, as far as is deemed necessary A rhomboidal wound will result, the two outer edges covered with skin

and the two inner with conjunctiva. If the opening is to be permanent, the conjunctiva is dissected up from the region of the commissure for some distance and attached to the skin of the lid by means of several sutures, the first stitch uniting the conjunctiva and skin at the angle of the wound, and the second and third approximating the skin and conjunctiva above and below the angle (3)

Instruments (fig 466) For the majority of eyelid operations a small number of instruments will suffice, but it is essential that they be in perfect condition. They comprise the following (1) cataract knife sharp enough to slit the kid of a testing drum without dragging (2) non-serrated tissue forceps without teeth, (3) dural hooks for retraction, (4) scissors of various shapes, both blunt and sharp-pointed, (5) mosquito forceps and lid clamps for the control of bleeding, (6) a lamina of steel or shell, or a horn plate for the protection of the eyeball, (7) eye speculum and fixation forceps, (8) needle holder, and atraumatic needles ½, ⅜ and ¼ curved (9) suture material, including #0000 catgut, ophthalmic silk, and horsehair, (10) instruments for skin, cartilage, and bone grafting

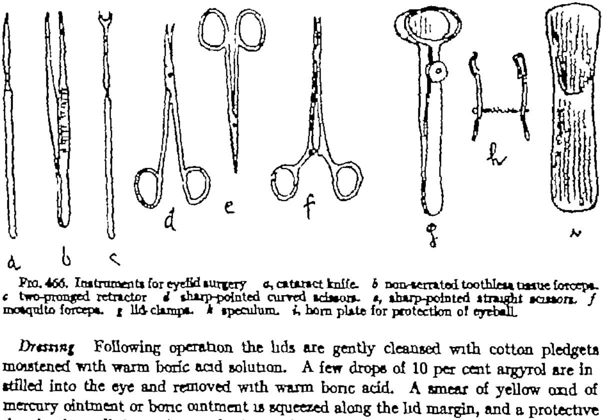


FIG. 466. Instruments for eyelid surgery *a*, cataract knife. *b* non-serrated toothless tissue forceps. *c* two-pronged retractor *d* sharp-pointed curved scissors. *e*, sharp-pointed straight scissors. *f* mosquito forceps. *g* lid clamps. *h* speculum. *i*, horn plate for protection of eyeball.

Dressing Following operation the lids are gently cleansed with cotton pledgets moistened with warm boric acid solution. A few drops of 10 per cent argyrol are instilled into the eye and removed with warm boric acid. A smear of yellow oxid of mercury ointment or boric ointment is squeezed along the lid margin, and a protective dressing is applied, consisting of a layer of xeroform gauze covered with several layers of dry gauze held in place by means of a roller bandage. Both eyes should be incorporated in this dressing, since the function of one eye affects the other After 4 days the unaffected eye is uncovered When a graft has been used, a pressure dressing is applied as detailed on page 124

REPAIR FOLLOWING LOSS OF TISSUE

For reconstructive purposes the eyelid consists of a covering membrane, the skin, a supporting structure of muscle, fascia, and a thick plate of fibrous tissue, and a lining

membrane, the conjunctiva. As is the case in other parts of the body, all of these tissues, when lost, must be replaced if the functional outcome is to be satisfactory. Defects of less than $\frac{1}{3}$ of the total lid thickness or $\frac{1}{3}$ of any of its coats can be corrected by direct approximation after the edges have been revivified, but if the involvement exceeds this amount, closure can be accomplished only by the addition of new tissue Replacement of an eyelid loss in which the muscle layer remains intact presents no problem, but when the entire lid has been destroyed, many difficulties arise, some of them insurmountable, and the results often leave much to be desired In these instances the surrounding skin is usually so damaged as to be unusable, functioning muscle can rarely be supplied, and as a consequence the newly constructed lid eventually becomes distorted by the unopposed action of the contiguous muscles

Replacement of Skin

The mere replacement of eyelid skin is a comparatively simple procedure and is accomplished by the use of full thickness skin grafts, thick or thin razor grafts, or flaps, the choice depending upon the character and location of the loss

Full Thickness Grafts It is interesting to note that the first full thickness skin graft on record was designed for the replacement of a skin loss of the lid (89) Such grafts are preferably obtained from the opposite lid, inasmuch as the skin in this region matches both in color and texture that which has been destroyed. The donor lid may furnish as much as $\frac{1}{2}$ of its surface area without consequent deformity or impairment of function Should more than this amount be necessary, an additional graft may be taken from the cephalo-auricular angle In such cases the graft from the upper lid is used to cover the lid margin, and that from the cephalo-auricular angle is utilized to cover the remainder of the defect An example of the combined use of grafts from these regions is illustrated in Figure 467

Technic. The bed which is to receive the graft is prepared If scar tissue is present, it is cleanly and thoroughly resected, regardless of its extent, so that the lid may fall into its normal position without tension Any scar tissue allowed to remain will interfere with the nutrition of the graft and by its contraction will have a tendency to distort the lid In order that the cutting and laying on of the graft may be facilitated, the bed is made to assume the form of a simple geometric figure, preferably an oval Hemorrhage must be absolutely controlled, as seepage of blood between the bed and the graft will interfere with the "take" The best means of securing hemostasis is through pressure, since ligature material acts as a foreign body and interferes with the adaptation of the graft to its bed Should ligation become necessary, however, the finest material is employed for the purpose The bed having been prepared, the eyelids are immobilized by a temporary tarsorrhaphy (p 839) An exact pattern of the defect is made in rubber, tinfoil, or cellophane, placed on the donor eyelid, and outlined by means of a skin incision. In order to facilitate the removal and subsequent emplacement of the graft, the skin margins are raised, and 4 anchoring sutures are passed through them at equidistant points and left long as tractors (fig 468) Separation of the graft is then completed by slicing it off with a cataract knife, care being taken not to include the subcutaneous tissue After complete separation the transplant is lifted out by means of the previously placed stay sutures, any remaining bits of subcutaneous tissue are carefully dissected off, and the graft is transferred to the bed pre-

pared for it. It is secured in place by the completion of the previously passed anchor sutures through 4 equidistant points on the recipient bed The remaining margins are approximated with interrupted sutures of horsehair or fine silk, the knots being tied on the side of the host. The margins of the wound in the donor eyelid are approximated without undermining, with fine interrupted silk sutures. A pressure dressing is placed over the graft (p 124) and a bandage incorporating both eyes applied After 4 days the donor eye is uncovered, and at the end of 10 days the pressure dressing is carefully taken off, all secretions are wiped away with moistened applicators, and

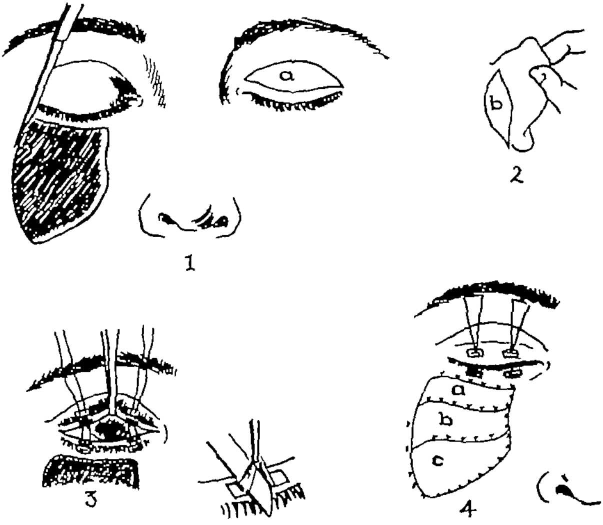


FIG 467 Replacement of skin loss *1* skin requiring removal outlined by incision. *a* skin graft outlined on upper eyelid. *2* skin graft outlined on cephalo-auricular angle. *3*, sutures passed through denuded areas on lid margins, to secure postoperative immobilization Insert shows method of denudation. *4* grafts sutured in place. *a* eyelid graft. *b–c* grafts from cephalo-auricular angles (Wheeler)

the sutures removed The graft is greased and a fresh pressure dressing applied for another week, after which time all dressings are discarded Gentle massage is instituted several times daily thereafter and continued for an indefinite period. The surgical adhesions of the lids are released as soon as they have served their purpose.

Razor Grafts Should the fellow eyelid or the skin of the cephalo-auricular angle be unusable because of previous scarring or disease, the next choice is a thick razor graft from some hairless region such as the inner side of the arm A full thickness

skin graft, except from the regions already mentioned, would be too bulky a substitute for the delicate skin of the lid and would interfere with its function

If the loss is limited to one eyelid, the graft is applied on a stent mold, after the method of Esser (25) (fig 469), as follows A transverse incision is made in the lid, extending from canthus to canthus All scar tissue is excised until the lids fall into easy apposition The margins of the wound are undermined for a few millimeters, care being taken to avoid damage to the musculature A mold of the defect is constructed in stent A razor graft of uniform thickness is cut from the inner side of the

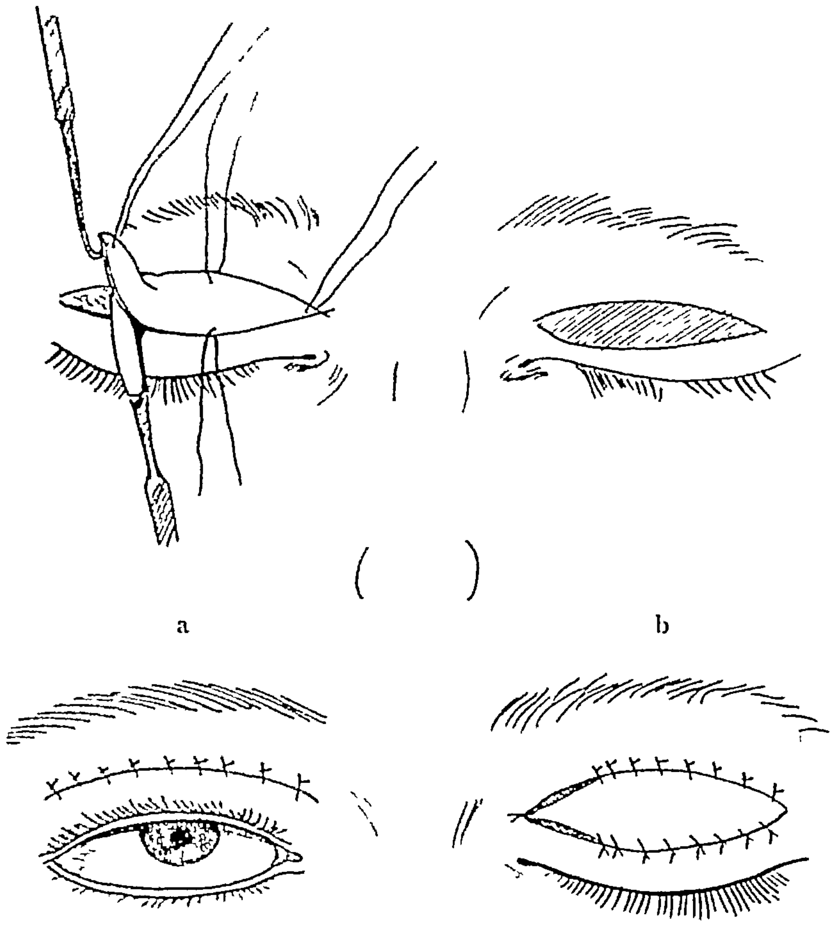


FIG. 468 Repair of eyelid defect by use of full thickness skin graft taken from fellow eyelid *a*, graft outlined to pattern Four anchoring sutures passed, to facilitate dissection Graft sliced off with cataract knife, care being taken not to include subcutaneous tissue *b*, prepared defect *c*, defect in donor lid closed *d*, graft secured in place by completion of previously placed anchor sutures Remaining margins approximated with fine silk, knots placed on side of host

arm and draped, raw side out, around the mold in such a way that its margins meet on the anterior aspect The graft-covered mold is then placed in position in its bed and secured by means of horsehair sutures passing from one skin edge to the other and picking up the free edge of the graft A pressure dressing is applied and left in place for 10 days At the end of this time the dressing is removed, the sutures are cut, and the mold is lifted out of its bed A drop of oil instilled between the mold and the graft will facilitate its removal All dead skin is trimmed away, the grafted area carefully cleansed, and the mold replaced, in order that there may be no contraction

of the graft. After this a protective dressing is applied. In 3 weeks the mold is permanently discarded, and massage is instituted and continued for an indefinite period

For cases in which the skin loss involves both upper and lower lids, Wheeler's (81) method is the most satisfactory The technic is as follows (fig 470) The bed is prepared and the eyelids adjusted and immobilized by a tarsorrhaphy, as described above. A large razor graft is cut from the inner surface of the arm or thigh, of sufficient size to overlap the skin margins of the bed. This graft is placed, epithelial side down, on a piece of greased rubber tissue, and a slit corresponding to the palpebral fissure is

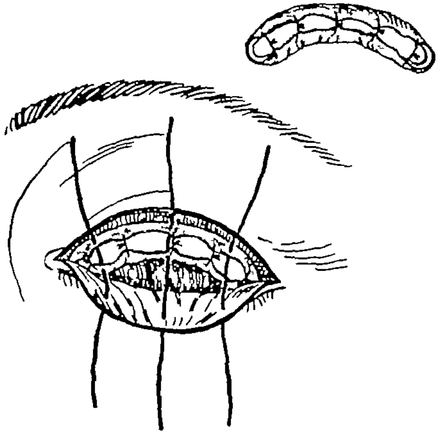


FIG 469 Repair of eyelid skin loss by razor graft on mold. Transverse incision made in lid, and all scar tissue excised, until lids fall into easy apposition. Mold of defect constructed in stent. Razor graft of uniform thickness cut from inner side of arm, and draped, raw side out, around mold in such a way that margins meet on anterior aspect. Graft-covered mold placed in defect and secured by sutures passing from one skin edge to the other picking up free edges of graft. Insert shows graft wrapped around mold.

made through both graft and covering to permit of drainage. The graft, together with its rubber tissue covering, is then placed over the defect, and a pressure bandage applied. In order to minimize the contraction that inevitably takes place in a razor graft, the adhesions between the lids are not disturbed for at least 3 months.

Flaps. In the absence of a healthy nourishing base for a graft, or in the case of a defect so deep that skin alone will not furnish sufficient thickness, flaps must be resorted to (p 204) On the whole owing to their weight and thickness, which have a tendency to cause an interference with function, they are less satisfactory than grafts, especially for the repair of the upper lid. This objection, however, can be partly overcome by limiting to a minimum the subcutaneous tissue in the free end of the flap, although

skin graft, except from the regions already mentioned, would be too bulky a substitute for the delicate skin of the lid and would interfere with its function

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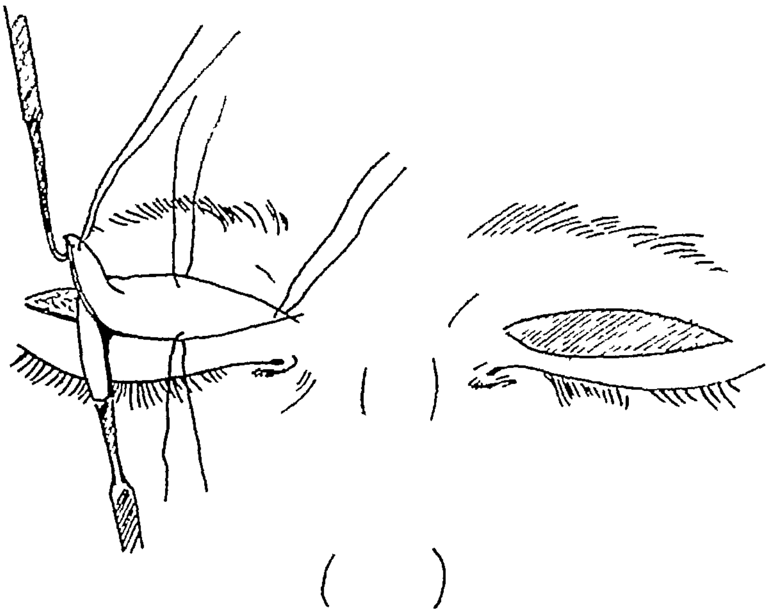
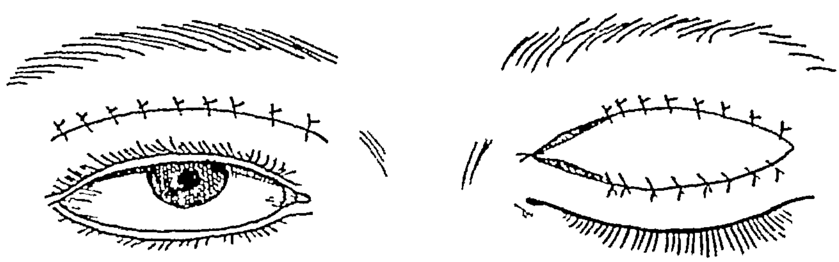


a b



c d

FIG 468 Repair of eyelid defect by use of full thickness skin graft taken from fellow eyelid *a*, graft outlined to pattern Four anchoring sutures passed, to facilitate dissection Graft sliced off with cataract knife, care being taken not to include subcutaneous tissue *b*, prepared defect *c*, defect in donor lid closed *d*, graft secured in place by completion of previously placed anchor sutures Remaining margins approximated with fine silk, knots placed on side of host

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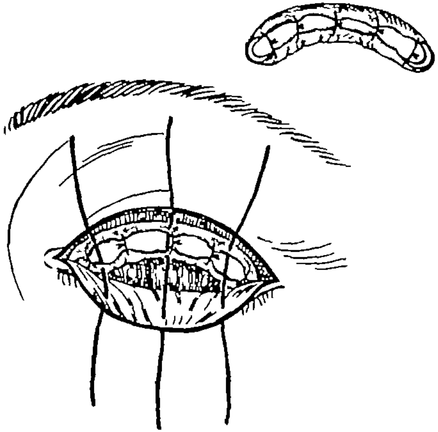

FIG 469 Repair of eyelid skin loss by razor graft on mold. Transverse incision made in lid, and all scar tissue excised, until lids fall into easy apposition. Mold of defect constructed in stent. Razor graft of uniform thickness cut from inner side of arm and draped, raw side out, around mold in such a way that margins meet on anterior aspect. Graft-covered mold placed in defect and secured by sutures passing from one skin edge to the other picking up free edges of graft. Insert shows graft wrapped around mold.

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this thinning, together with the necessarily narrow pedicle, decreases the vitality of the flap Therefore, it should be taken from a locality which will permit of its containing a definite blood vessel, and should be brought into the defect as quickly as possible and with a minimum of rotation and trauma Damage from suturing can be reduced if the needle is passed through the flap before it is carried through the margin of the defect In order to compensate for shrinkage, the flap should be cut $\frac{1}{3}$ larger than the wound If there is any doubt as to the viability of the flap, it is raised, resutured in its bed, and transplanted at a later date (p 213)

Seldom are two defects of the eyelids exactly alike as to size, shape, and location, but by a modification of the different varieties of flaps about to be described the demands of the particular case may be met Some type of advancement or rotation flap from the immediate vicinity is ordinarily employed, owing to the better color and texture match which these flaps afford, but if for any reason the surrounding skin is un-

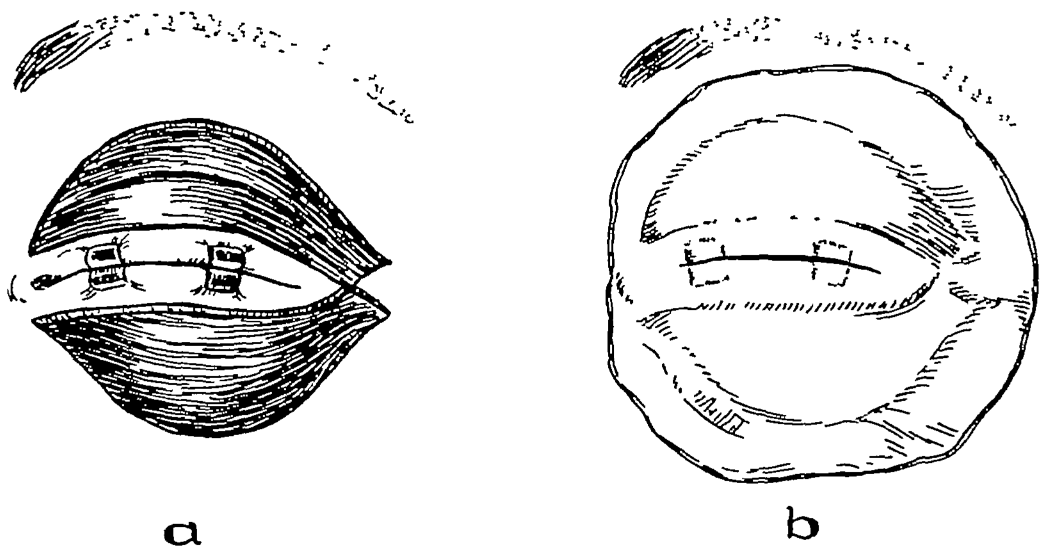


FIG 470 Use of razor graft to replace skin loss involving both lids *a*, scar tissue removed and lids immobilized by temporary tarsorrhaphy *b*, razor graft cut from inner surface of arm and placed, epithelial side down, on piece of greased rubber tissue Slit made through graft and cover along line of palpebral fissure for escape of secretions Graft, together with rubber cover, placed over defect Pressure bandage applied (Wheeler)

usable, or if the additional scarring left after closure of the secondary defect would be objectionable, tissue must be brought from a distant part, such as the neck, chest, or arm

(1) *Repair by Advancement Flaps* Advancement flaps have the advantage that they are well nourished, there is no pedicle requiring severance, unlike grafts, they require no pressure dressing, and less scarring is occasioned than by other methods of reconstruction

Von Imre (43, 44) repairs eyelid defects of any shape or size by sliding into the defect through the shortest possible arc the adjacent skin of the cheek, employing elliptic incisions about four times the length of the necessary sliding In order to facilitate rotation and prevent buckling when it becomes necessary to equalize the difference in length between a large and a small arc, triangles are excised after the plan of Burow (15) For example, in order to cover a skin defect at the inner canthus, an incision is made in the skin in the form of the letter S extending from the forehead

above the root of the nose into the cheek region below the eye. At each end a small triangle is removed. After free undermining the upper flap is slid downward and the lower flap slid upward over the defect. Figure 471 is self-explanatory. For the closure of a triangular defect of the lower lid a horizontal incision is carried laterally from the outer canthus for a distance equal to the length of the defect. At the end of this

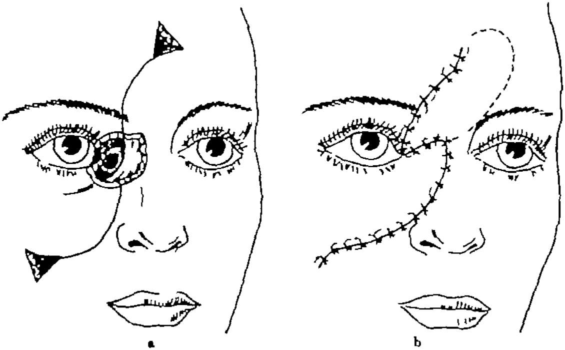


FIG. 471 Repair of inner canthal defect by advancement flaps *a*, flaps outlined. Triangles removed at either extremity of incision *b* upper flap slid downward and lower flap upward, and margins of wound approximated. Dotted line indicates extent of undermining (von Imre)

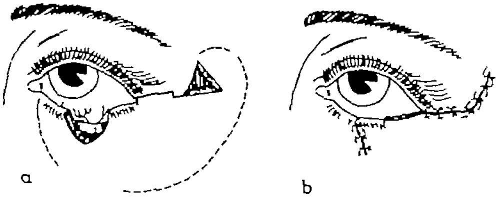
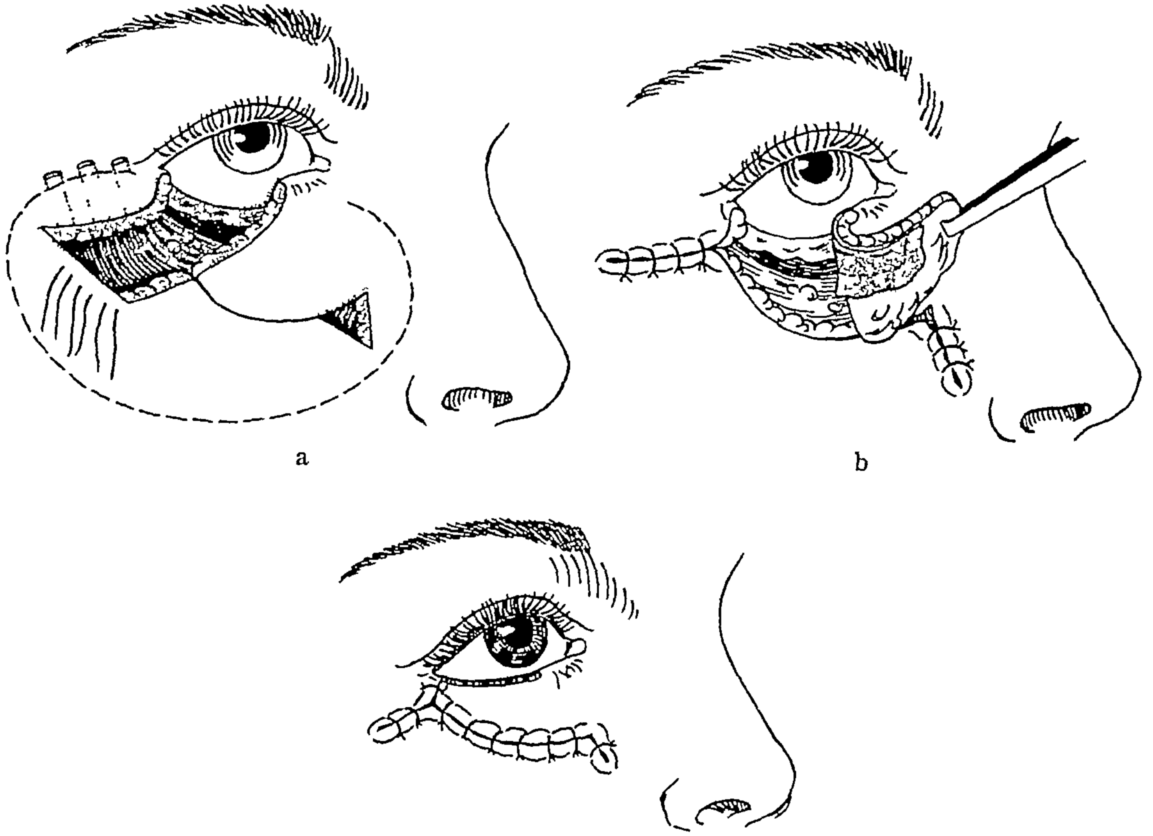


FIG 472 Repair of triangular defect in central portion of lower lid by advancement flap *a* horizontal incision equaling length of defect carried laterally from outer canthus. Triangle excised at outer end of incision Dotted line indicates extent of undermining. *b* flap shifted inward, and margins of wound approximated. (von Imre)

incision a triangle is excised its base being formed by a prolongation of the incision just described. The tissues are undermined and the flap slid medially into the defect and sutured (fig 472) This method may also be employed for the reconstruction of full thickness losses, as indicated in Figures 473–474

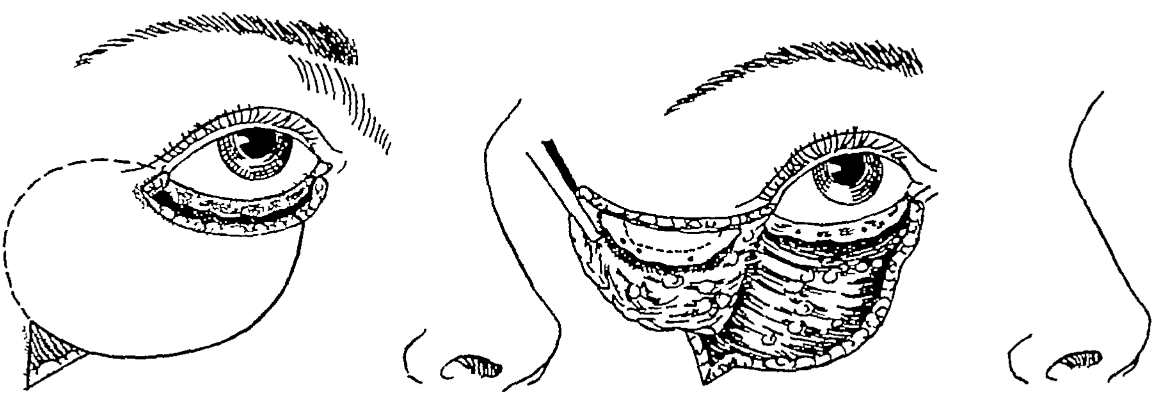
Esser (24) operates in a similar manner, closing defects of any size by advancing the contiguous cheek and neck tissue into them Figure 475 is self-explanatory

For triangular skin defects in the lower lid the method of Dieffenbach (19) can sometimes be used to advantage The technic is as follows (fig 476) The defect is



a b c

FIG 473 Reconstruction of full thickness loss of lower lid by lined advancement flap *a*, flap outlined Triangle of skin removed, to prevent buckling Mattress-sutures placed for approximation Dotted line indicates extent of undermining *b*, graft of tarsal cartilage and conjunctiva cut from upper lid and sutured to under surface of flap *c*, flap in place, and skin margins approximated (von Imre)



a b

FIG 474 Reconstruction of full thickness loss of lower lid margin by lined advancement flap *a*, flap outlined Triangle of skin removed, to facilitate rotation Dotted line indicates amount of undermining *b*, under surface of flap lined with graft of conjunctiva and tarsus from upper lid (von Imre)

pared in the form of a triangle, its base lying just below the lid margin The base of the defect is then prolonged through the skin toward the temporal region for a distance equal to its length From the outer extremity of this incision a second incision is

carried vertically downward, terminating on a line with the apex of the defect. The quadrilateral skin flap thus outlined with its pedicle below is undermined, shifted medially into the defect, and sutured to its upper and medial margins, one or two sutures being inserted into the canthal ligament for support. The secondary triangular defect is drawn together as much as possible without tension, and any remaining raw surface is skin-grafted. In order to secure a more perfect fit, permit of easier rotation with less torsion, and minimize the secondary defect, the flap may be

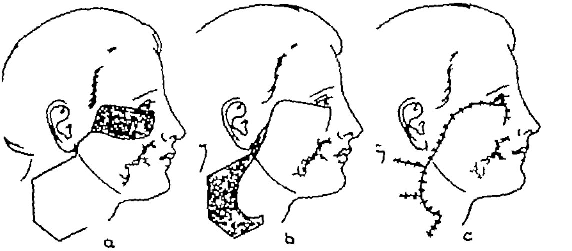


FIG. 475 Repair of extensive defect of lower eyelid by advancement flap taken from cheek and neck. *a* shaded area shows defect, solid line, outline of flap *b* tissues undermined and advanced upward over defect. *c* wound margins approximated. (Esser)

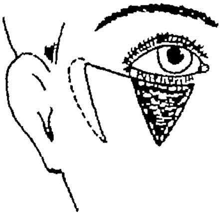


FIG. 476. Repair of triangular skin defect of lower lid Horizontal incision carried from base of triangle outward for distance equal to base of triangular defect. Another incision carried vertically downward. Quadrilateral flap thus formed shifted inward, to cover defect. Secondary wound approximated directly or skin-grafted Dotted line indicates extent of undermining (Dieffenbach).

cut in such a manner that the pedicle will be narrower than the free end and its shape more triangular than quadrilateral (6 11)

For the obliteration of quadrilateral defects extending transversely across the lower lid repair by direct advancement of the defect margins is often satisfactory provided the loss of skin is not too great. The technic is as follows (fig 477) The defect is pared and its long sides extended to form a medial and a lateral flap These flaps are undermined for a distance sufficient to permit of their advancement and approximation in the midline. To relieve buckling, small triangles are excised, as indicated in

the diagram The objection to the procedure is the tension exerted on the flaps, which may result in sloughing This can be overcome to some extent if the upper margins of the flaps at the outer canthus are fixed to the skin, temporal ligament, and periosteum

Another form of advancement flap is that of Burow (15) The details of the technic are as follows (fig 478): The defect is outlined in the form of a triangle, as in Dieffenbach's operation The base of the defect is prolonged laterally for a distance equal

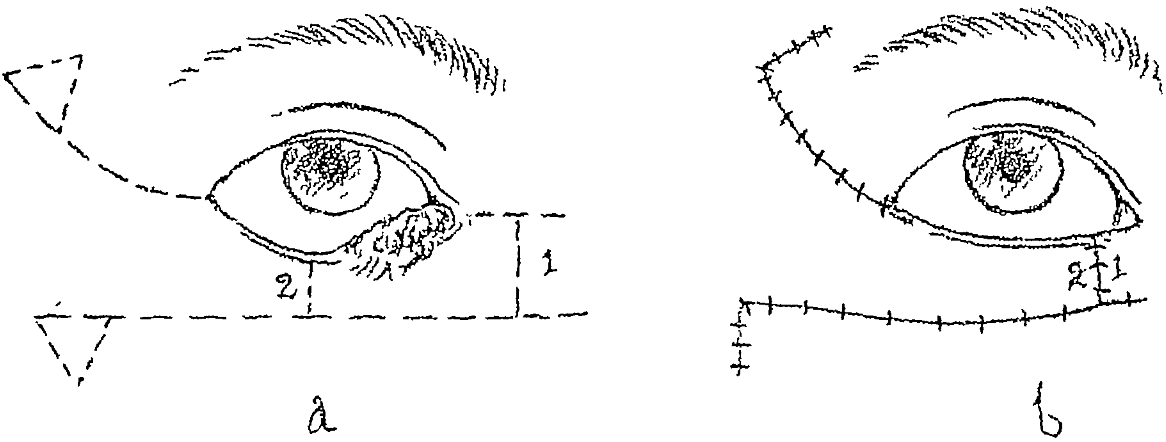


FIG 477 Repair of quadrilateral defect of lower lid by direct advancement of defect margins *a*, pathologic tissue excised, and defect margins extended to form flaps *1* and *2* Skin triangles excised, to prevent buckling *b*, flaps undermined and approximated (Celsus-Knapp)

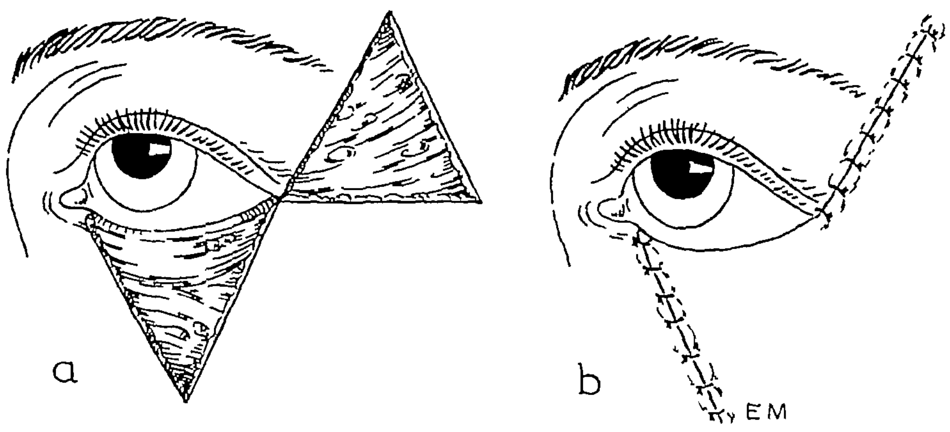


FIG 478 Repair of triangular defect of lower lid by advancement flap *a*, base of defect prolonged laterally for distance equal to its length Two oblique incisions made, converging above Triangle of skin thus outlined excised *b*, cutaneous flap lateral to defect dissected up and slid medially, thus obliterating both triangular raw surfaces (Burow) (This operation is rarely applicable, as it entails an unwarranted sacrifice of skin)

to its length, and from each end of this incision two oblique ascending incisions are made, converging above The triangle of skin thus outlined is excised, and the cutaneous flap lateral to the defect is dissected up and slid medially, so as to obliterate both triangular raw surfaces While this procedure is occasionally applicable, ordinarily it entails an unwarranted sacrifice of skin

(2) *Repair by Rotation Flaps* Transverse rectangular skin defects of moderate size on the lower lid may be repaired by a bridge flap from the upper lid (78) thus (fig. 479): After immobilization of the lids by a tarsorrhaphy, 2 curved parallel

incisions are made in the upper eyelid, the first along the superior border of the tarsal cartilage, and the second above it at a distance corresponding to the width of the defect to be covered. The incisions are carried through the fibers of the orbicularis muscle down to, but not including, the tarsal cartilage. The musculocutaneous layer is undermined, and the double-pedicled bridge flap thus formed is drawn down, hammock fashion, to cover the revivified defect and sutured in place. The wound

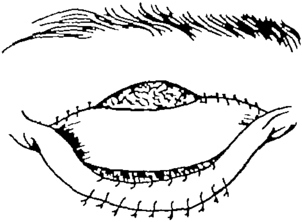


FIG 479 Repair of moderately sized rectangular defect of lower lid by bridge flap taken from upper lid. For details, see text. (Tripier)

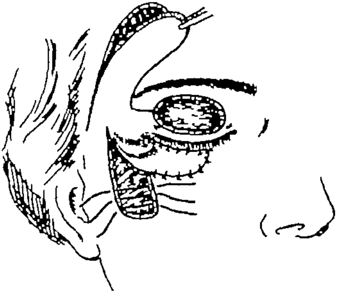


FIG 480. Repair of oval defects involving both lids by swinging advancement flaps. Temporal flap employed for upper lid. Medial arm of incision prolonged into defect, to obviate necessity of severing pedicle. Outer incision prolonged sufficiently to permit of easy rotation. Cheek flap used to cover lower lid defect. (Fricke Letenneur von Langenbeck)

in the upper lid left after the removal of the flap is drawn together by direct approximation, interrupted silk sutures being used. At the end of 2 or 3 weeks the pedicles are cut the ends of the flap are fitted into the defect, and the stumps returned to their original sites. Some secondary modeling will usually be necessary to secure the desired end results. The adhesions are released after the reconstruction is completed.

For the covering of oval defects of either lid, Fricke's (28) method may be employed (fig. 480) The details are as follows The pathologic tissue is excised through

out its entire extent, hemorrhage is controlled, and the lids are closed by a tarsorrhaphy. The defect in the lid is pared to assume an oval shape, and a pattern of it is made in rubber tissue If the upper lid is to be reconstructed, the pattern is placed on the temporal region in such a way that the free end of the flap is directed upward and the pedicle is adjacent to the defect The pattern is outlined by an incision through the skin The medial arm of the incision outlining the flap is prolonged into the defect, so as to obviate the necessity of later severance of the pedicle, and the outer arm is prolonged sufficiently to permit of easy rotation The flap is raised, rotated into its bed, and sutured in place The secondary defect is closed by direct approximation

FIG 481 Repair of lower lid defect by semilunar cheek flap *A*, flap outlined *B*, flap swung into defect and united to its pared margins Sutures placed for closure of secondary defect (Fricke) (The semilunar shape of the flap permits of its easy adaptation to the lid margin)

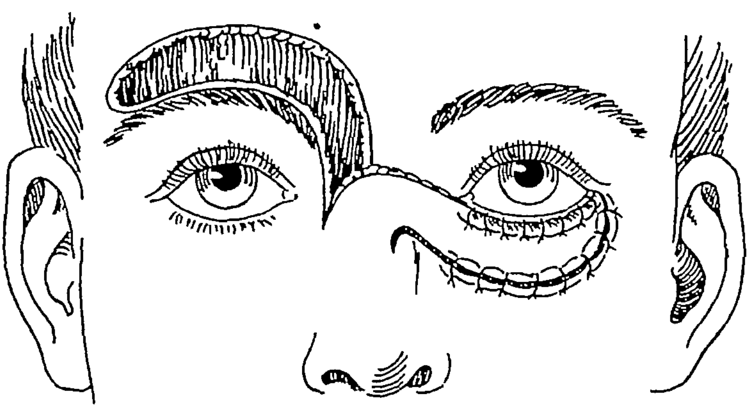


FIG 482 Repair of lower eyelid defect with rotation flap pedicled on glabella Forehead flap carrying line of hair from opposite eyebrow to replace eyelashes swung into defect and sutured in place. (Meyer)

after the skin on the temporal side has been undermined Undermining of the nasal side, however, is to be avoided, as it may displace the eyelid For the replacement of a similar loss in the lower lid, the same technic is employed, except that the flap is cut from the cheek, pedicled above, and turned up instead of down to cover the defect (3) (fig 480) One of the chief drawbacks to the use of this flap is its oval shape which prevents its easy adaptation to the lid margin and renders closure of the secondary wound difficult These objections may be overcome to a certain extent by cutting the flap in a semilunar shape, so that its shorter concave edge will more easily adapt itself to the shape of the lid margin (54, 56) (fig 481)

Meyer replaced a loss of lower lid skin with a forehead flap carrying a row of hair

from the opposite eyebrow The flap was pedicled on the glabella and swung into the defect in such a manner that the line of eyebrow hair replaced the lost eyelashes (fig 482)

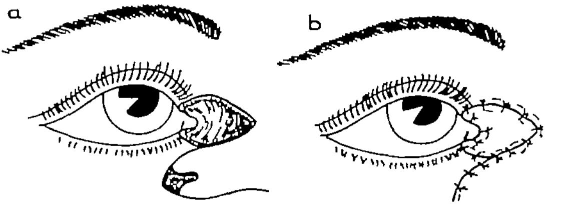


FIG. 483 Repair of inner canthal defect by swinging advancement flap *a*, flap outlined. Free end split into 2 lobes, to fit canthus. *b* flap swung into defect and sutured in place. (Hasner-Szymanowski)

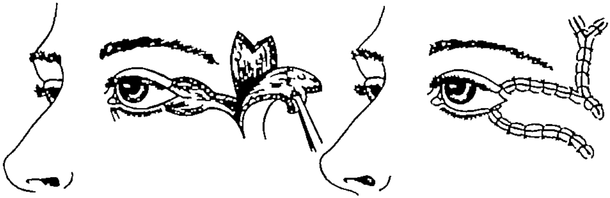


FIG. 484 Repair of outer canthal defect by swinging advancement flap taken from temporal region *a* flap raised. *b* flap swung into defect and sutured in place. (Hasner Artha)

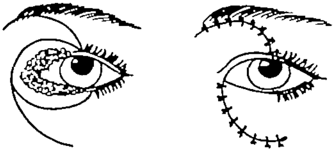


FIG. 485 Repair of inner canthal defect by swinging advancement flaps taken from above and below defect.

A modification of Fricke s flap can often be employed to advantage for defects in the vicinity of the inner or outer canthus (37) thus The defect is excised roughly in the form of an oval If it is in the region of the inner canthus, the flap is taken from the nasal side pedicled on the nose or glabella (fig 483) if near the lateral canthus, it is obtained from the temporal side, pedicled below (fig 484) The free edge of the

flap is divided into 2 lobes, so that one arm will fit into the upper and the other into the lower palpebral defect Other forms of flaps used for the correction of defects about the inner and outer canthi are illustrated in Figures 485–486.

An "island artery flap" taken from the temple and including in its pedicle only the temporal artery with its accompanying veins, nerves, and lymphatics held together by loose connective tissue (25, 63) provides an ideal blood supply, an efficient outlet, and innervation, and can be used for any type of skin defect about the lids Details of the technic of its formation have already been described on page 231 (fig 136)

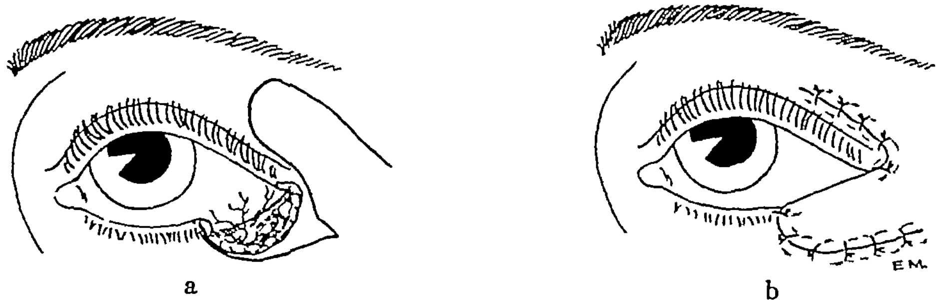


FIG 486 Repair of outer canthal defect by swinging advancement flap taken from upper lid. *a*, flap outlined *b*, flap swung into defect and sutured in place

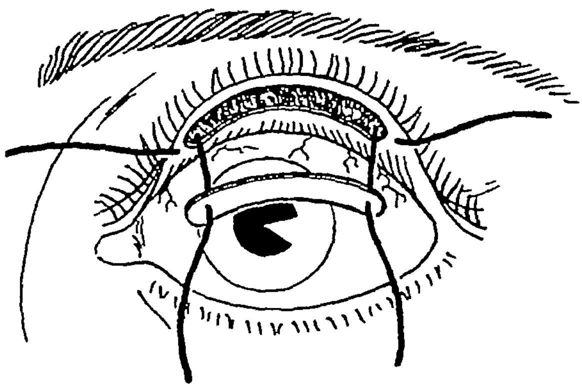


FIG 487 Repair of conjunctiva with mucous membrane graft

Replacement of Conjunctiva

A loss of mucous membrane must of necessity be replaced, otherwise, the lid will become either distorted by cicatricial contraction or adherent to the eyeball, with its motion restricted and its function impeded

Replacement with Mucous Membrane. The ideal replacement material for conjunctival defects, especially in the presence of an intact eyeball, is mucous membrane, but unfortunately this material is limited in quantity and can therefore be used for the repair of minor losses only. Such grafts are obtained either from the inner surface of the lower lip or from the mucosa of the cheek It has been suggested that they be taken from the concha, but the sacrifice seems unwarranted

The bed is prepared in the usual manner A pattern of the defect is made in oiled silk or rubber tissue, placed on the donor area, and cut around If the graft is to be taken from the buccal mucosa, care must be exercised to avoid injury to the parotid duct The graft is dissected off and its under surface trimmed in the same manner as

a skin graft (fig 80) After hemostasis has been secured, the margins of the defect in the donor area are closed by direct approximation The graft is implanted into the prepared recipient area and anchored by means of 4 equidistant sutures (fig 487) In order that the knots may cause no undue irritation of the cornea, the threads are best passed in the form of a double-armed suture, entering the conjunctival surface and emerging on the skin, where they are tied. This will also permit of the removal of the stitches without any disturbance of the graft. The lids are then approximated and a pressure dressing applied. The after treatment is the same as that following the implantation of a skin graft.

Replacement with Skin Grafts. While it is a counsel of perfection to replace lost tissue by a tissue similar in structure, yet in the case of large defects of the palpebral conjunctiva one must ordinarily be content to repair the loss with a thin razor graft, since, as has been said before, the supply of mucosa necessary for such a repair is ordinarily unavailable in the quantity required. Although theoretically skin grafts would appear to cause irritation from the piling up of epithelium on the surface of the graft (76), as an actual fact no harm will result from their use, provided the graft is cut sufficiently thin, since the exfoliated epithelial cells are washed away by the constant flow of tears.

The graft is procured from some hairless region of the body, such as the inner side of the arm. For females Clay and Baird (16) suggest the membrane of the vestibule between the inner margin of the labia minora and the outer margin of the hymen, and for males that from the inner surface of the prepuce. They advocate the use of skin from these regions on the grounds that it is thin, contains no hair and little subcutaneous fat, has the appearance of conjunctiva, and does not desquamate.

For mucous membrane defects involving the upper or lower fornix an Esser inlay graft gives uniformly good results. The technic of its implantation is briefly as follows After the liberation of the eyelid from the eyeball and the removal of all scar tissue a piece of softened stent is pressed into the defect and allowed to harden. It is then removed and a thin razor graft, obtained in the usual manner (p 133), is wrapped around it, raw surface outward, and the graft-covered mold is buried in the pocket. The mold is immobilized by bringing the margins of the wound together over it and the usual pressure dressing is applied. At the end of 10 days the original incision is opened and the mold lifted out. In order to prevent contraction, the mold should be worn for several weeks thereafter, being removed daily for purposes of cleansing (25) An appliance designed to hold the mold in place is shown in Figure 488

When the conjunctiva of both the upper and lower eyelids is to be replaced and the sight of the eye is lost, the lids are separated from the underlying structures for a distance of 1 to 2 mm. beyond the orbital margins, the dissection being carried out in the plane just beneath the tarsus. They are then everted, and all cicatricial tissue is removed, so that a clean base remains. Hemorrhage is controlled by pressure. Frequently an external canthotomy will be necessary to facilitate the dissection. The wound is freed of all blood-clots, and a mold is constructed to carry the graft. This mold should be of the proper size and shape to fit into the newly formed fornices and permit of the temporary approximation of the eyelid margins over it. The mold is covered with a thin razor graft, raw surface outward, the edges of the transplant

meeting on the anterior surface along the line of the palpebral fissure, and is placed on the denuded area The eyelids are approximated over it and secured by means

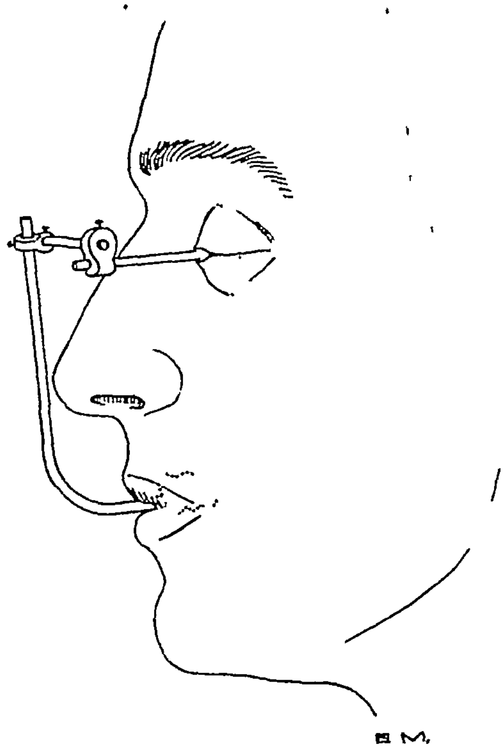


FIG 488 Prosthetic appliance designed to hold graft-covered mold in place (Fry)

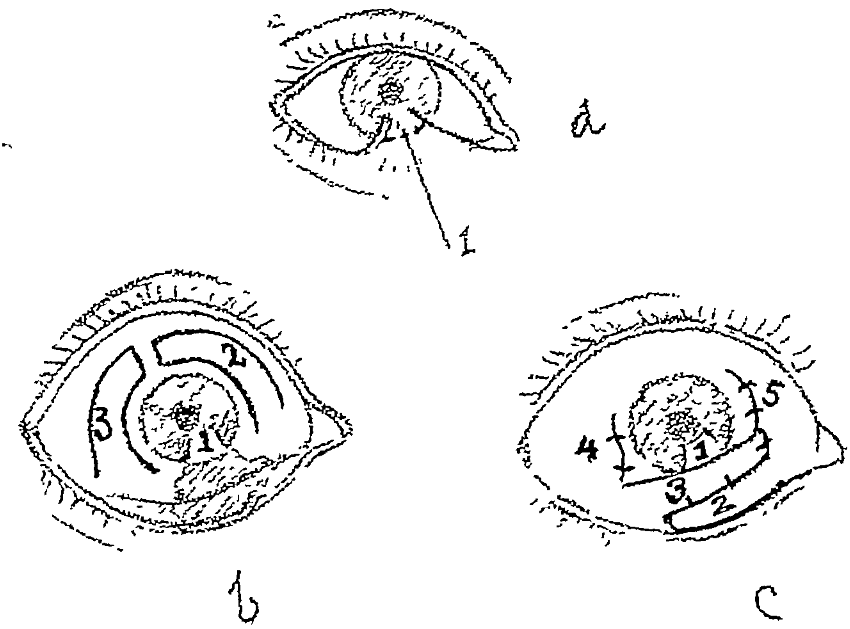


FIG 489 Repair of bulbar conjunctiva by swinging advancement flaps *a*, defect *1*, line of incision for removal of scar tissue *b*, pathologic tissue excised *2–3*, conjunctival flaps outlined *c*, flaps *2–3* raised and swung into defect Secondary wounds *4–5* closed (Teale)

of 2 or 3 mattress-sutures without denudation of the margins After this the usual pressure dressing is applied At the end of 10 days the bandage is removed, the sutures divided, and the mold extracted Excess portions of the graft are cut away,

and the eye is cleansed with normal salt solution. The mold is reinserted and worn until all danger of contraction has ceased, at which time it is replaced with a prosthesis.

In case the eye is intact, the graft is applied in a similar manner, except that the mold and the graft which has been draped over it are perforated in the center to avoid undue pressure on the cornea.

Losses of bulbar conjunctiva may be replaced with contiguous flaps taken from the neighboring conjunctiva or with mucous membrane grafts. Flaps are employed if sufficient uninjured conjunctiva remains to permit of direct approximation of the secondary wound. They may be cut on a single pedicle or a double pedicle in the form of a bridge. In either case the scar tissue is excised until all restriction to the movement of the eyeball has been removed. A flap large enough to cover the raw surface is outlined on the ocular conjunctiva, raised, rotated into the defect, and fixed in place. The secondary wound is approximated directly The general plan is shown in Figure 489 Grafts are applied in the same manner as described for the palpebral conjunctiva.

Simultaneous Replacement of Cover Lining and Support

When the full thickness of the lid has been destroyed, all layers—namely, cover, lining and support—must be replaced. To supply cover and lining, any of the flaps previously described for skin replacement may be lined with a skin graft and transferred to the defect at a later date. Support is furnished by means of a cartilage graft taken from the tarsal plate of the opposite eye or from the ear The details of the technic are briefly as follows Beneath the free extremity of the proposed flap the skin is incised and undermined and a pocket thus created. Into this pocket is placed a mucous membrane graft or a thin razor graft of skin on a flat stent mold, and the incision is closed. It is essential that the location of the graft be so planned that when the flap is rotated the lining will fit exactly into the conjunctival defect without tension. Two or 3 weeks later the margins of the defect are pared in the form of a simple geometric figure, such as a rectangle or triangle, and the previously lined flap, shaped to fit the defect, is raised and shifted into it. The lining of the flap is sutured to the conjunctival surface at the edges of the defect with #000000 catgut sutures, and the skin surface is united to the contiguous skin with fine silk The secondary defect is then closed by direct approximation or is skin-grafted, and a light pressure dressing is applied. At a later date a properly shaped piece of cartilage is introduced subcutaneously to furnish support

Repair of Partial Full Thickness Losses. For the repair of a small triangular defect of the lower lid the technic of the Estlander Abbe (1, 26) operation for lip reconstruction may be adopted (fig 490) The edges of the defect are defined and freshened in the form of a triangle. A triangle of full thickness tissue corresponding in size to that of the defect is cut from the upper lid, remaining attached only by a small pedicle at the lid border This flap carrying the palpebral artery, is swung into the defect through an arc of 180 degrees and sutured in place. After vascularization has taken place, the pedicle is severed. Minor secondary operations will be necessary at a later date to secure the desired end results.

For small rectangular defects of the lower lid, lining and support may be obtained from the upper lid and cover by means of a graft or a flap from the temporal region

(51) The technic is as follows (fig 491) The upper lid is everted and an incision made through the conjunctiva and half the thickness of the tarsus 2 to 3 mm from the edge of the lid and parallel to it, the length equaling that of the defect to be filled in From the ends of this incision 2 perpendicular incisions of the same depth are carried as far as the fornix The tissues are undermined, and the flap, pedicled on

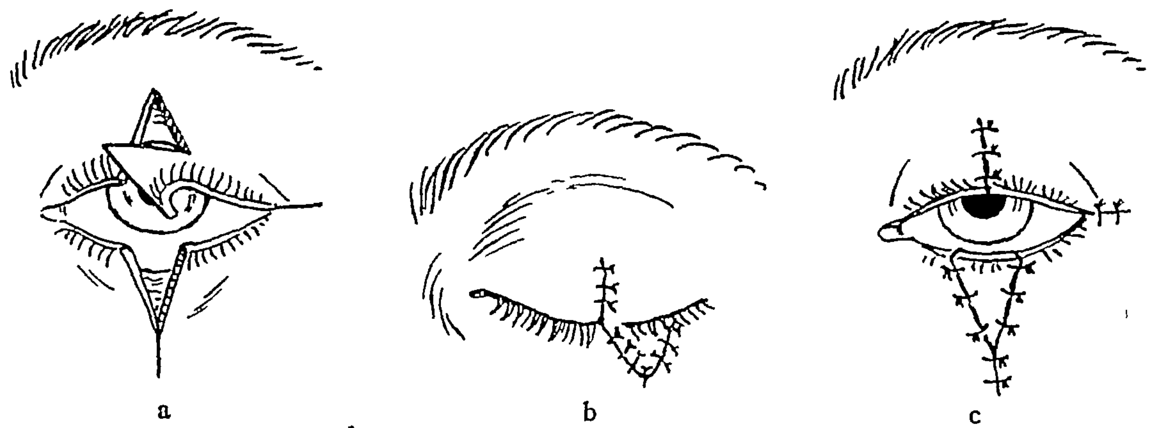


FIG 490 Reconstruction of triangular full thickness loss of lower lid by flap taken from upper lid *a*, flap pedicled on palpebral artery and corresponding to size and shape of defect raised from upper lid *b*, flap swung through arc of 180 degrees and sutured into defect Secondary wound closed by direct approximation *c*, pedicle cut after vascularization (Estlander-Abbe)

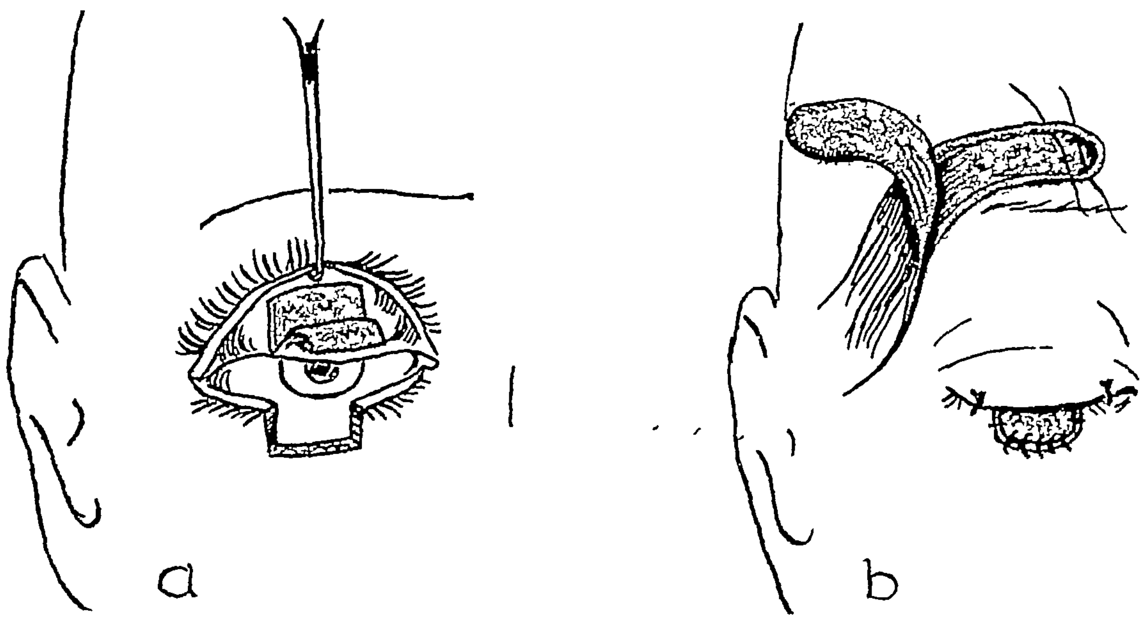


FIG 491 Repair of quadrilateral defect of lower lid *a*, flap of conjunctiva and half thickness of tarsus turned down from upper lid hinge-fashion *b*, flap sutured into defect, conjunctival surface facing eyeball Temporal flap raised, to cover raw surface (Koellner) (In lieu of a flap, raw surface may be skin-grafted)

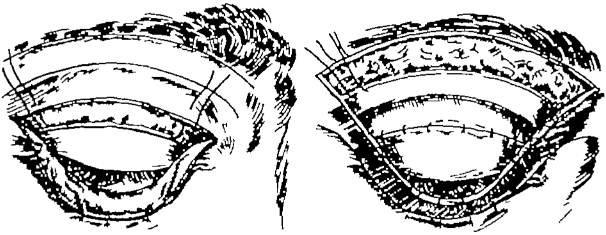
the fornix and consisting of conjunctiva and half the thickness of the tarsus, is turned down hinge-fashion, so that the conjunctival surface apposes the eye and the raw surface is directed outward The denuded area left in the upper lid is covered with a mucous membrane graft (p 160). The flap is then sutured into the revivified margins of the defect, and the lids are immobilized.

The cover is supplied by a skin graft taken from the opposite eyelid (fig 468), a

contiguous flap (fig 491), or a bridge flap from the upper lid after the manner of Tripier (78) (fig 479), and a light pressure dressing is applied After vascularization the lids are separated by severing the pedicle of the lining flap, and the raw margins are covered by approximating the conjunctiva to the skin.

Long narrow defects of the lower lid may be reconstructed by a modification of the Tripier operation (58) (fig 492) as follows A double-pedicled flap of skin is raised from the upper eyelid, rotated at an angle of 180 degrees, so that the skin side faces inward, and sutured to the remaining conjunctiva of the lower lid. The outer raw surface of the flap is covered with another double-pedicled flap from the upper part of the same eyelid, cut in such a fashion as to carry a line of eyebrow hair to replace the eyelashes. Or the cover may be supplied by a pedicle flap taken from the vicinity

For the repair of a triangular defect of the upper lid Spaeth (76) employs a flap previously lined with mucous membrane.



a b

FIG. 492 Repair of long narrow defect of lower lid by 2 bridge flaps taken from upper lid a two double pedicled flaps outlined. Lower flap raised, rotated 180 degrees, and sutured, skin side in, to remaining conjunctiva of lower lid, to supply lining b upper flap carrying line of hair to replace eye lashes brought down, to supply covering. (Lindemann)

Repair of Total Full Thickness Losses. In the earlier methods reconstruction of a total lid loss was accomplished by means of flaps carrying cover and lining only, no provision being made for replacement of the supporting structure. For example, Kalb (47), to restore a lower lid, employed a cheek flap pedicled at the lateral canthus. The free end extended to a point above and lateral to the corner of the mouth and incorporated a portion of the full cheek thickness. The flap was rotated in such a manner as to bring the patch of oral mucosa into the conjunctival defect. The secondary wound was closed by direct approximation. The pedicle was severed after 3 weeks and the stump replaced in its original position. Kaz (48) (fig 493), in an endeavor to reconstruct an upper lid, raised a temporal flap pedicled at the lateral canthus, turned it, skin side inward, over the defect, and sutured it to the edges of the remaining mucous membrane. As a cover he used a forehead flap incorporating a part of the frontalis muscle and with its pedicle in the temporal region just above the lining flap This flap was cut to carry eyebrow hair to replace the cilia. The above procedures produced at best a lumpy substitute for the eyelid, and today these methods of reconstruction are obsolete.

For the restoration of a complete loss of the lower lid Hughes (42) modifies the operation of Axenfeld (7), employing skin from the cheek for cover, and tarsus and

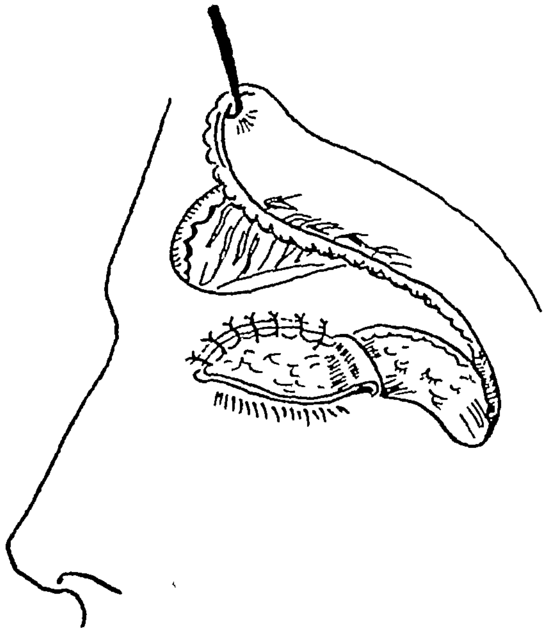


FIG 493 Replacement of total loss of upper lid by 2 temporal flaps, one turned down for lining, and the other superimposed, to supply cover (Kaz)

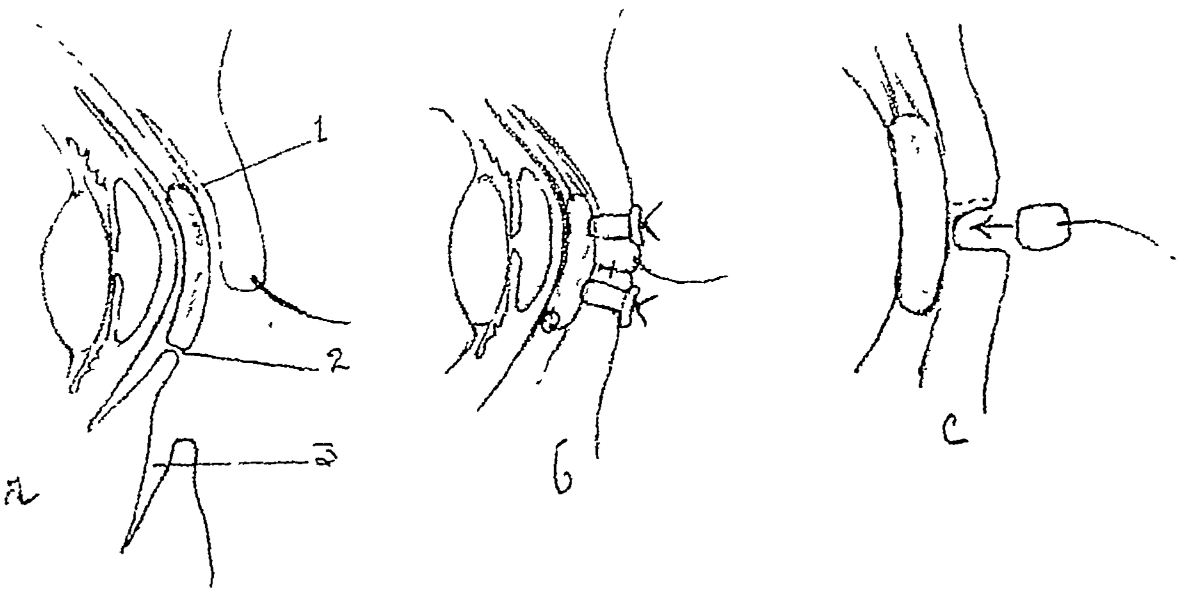


FIG 494 Reconstruction following complete loss of lower lid *a1*, skin of upper lid separated from tarsus *2*, tarsus pulled down, to be united to remaining conjunctiva of lower lid *3*, skin of cheek undermined *b*, upper tarsus united to lower conjunctival remnant, to complete inner coat Skin of cheek raised and attached to tarsus and upper lid *c*, replacement of lower eyelashes Trough dissected down to tarsus, to receive hair-bearing transplant from opposite eyebrow For details, see text (Hughes)

conjunctiva from the upper lid for support and lining. He operates thus (fig 494) *First stage* The skin margin of the defect is undermined for a distance sufficient to permit of its being drawn upward without tension to the level normally occupied

by the lower lid margin. The upper lid is split transversely into 2 layers along the gray line, the dissection being carried upward to a level about 3 mm. above the upper margin of the tarsus, care being taken to avoid injury to the attachment of the levator palpebrae. The lower border of the upper tarsus is pared and united with the pared conjunctival remnant of the lower fornix by means of #000 silk, the knots being tied on the conjunctival surface (fig 494-b) The previously undermined cheek skin is then drawn upward and secured to the anterior surface of the lower half of the tarsus by 3 double-armed black silk sutures (fig 494-b), in such a way that the upper border of skin comes to lie midway between the upper and lower margins of the tarsus. The superficial layer of the upper lid is similarly attached to the anterior surface of the upper half of the tarsus, so that the lashes will occupy a line parallel and adjacent to the lower edge of the skin across the midportion of the tarsus. The two edges of skin are joined together by means of a subcuticular suture, and the cilia are held against the skin of the upper lid with collodion A sheet of greased rubber tissue is placed over the area and overlaid with a pressure dressing which is left in place for 6 days. Subsequent dressings are applied at 5-day intervals for 3 weeks.

Second stage Six weeks later a row of eyelashes is transplanted along the margin of the proposed lower lid. A transverse trough is dissected down to the tarsus immediately below and parallel to the cilia of the upper lid (fig 494-c) A strip of hair bearing skin shaped to fit the trough thus made is cut from the lower nasal portion of the opposite eyebrow, reversed to make the hair assume the proper direction, laid in the trough, and sewn in place. A sheet of rubber tissue is placed over the area and overlaid with a pressure dressing which is left in place for a week The eye is redressed on the twelfth day and the dressing discarded permanently on the seventeenth. Part of the sutures are removed at the time of the first dressing and the remainder at the second.

Third stage After an interval of 3 months the palpebral fissure is constructed by means of a transverse incision made through the full thickness of the lids, between the two rows of eyelashes. The raw margins are covered by approximating the palpebral conjunctiva to the skin.

The same principle may be applied to the replacement of the upper lid, as follows The margin of the lower lid is denuded An incision is then made through the skin along the lower orbital margin, and the lid is elevated and sutured to the pared margin of the remainder of the upper lid. The secondary skin defect caused by the elevation of the lower lid is skin-grafted. At a second stage a row of eyelashes is grafted on the site of the proposed palpebral fissure, and at a third stage the fissure is constructed by means of a horizontal incision through the lid. Finally, the raw surfaces of the cut margins are covered by approximating the conjunctiva to the skin, fine silk sutures being used.

Buedinger (14) and Meller (61) reconstructed a lower lid with a temporal flap pedicled at the outer canthus. The technic is as follows (fig 495) On the inner surface of the flap over the area destined to cover the defect, a graft of cartilage and skin from the back of the ear was implanted. This flap, containing lining, support, and cover, was rotated and sutured into the defect.

Gillies (32) reconstructs the lower lid in the following manner (fig 496) A thin strip of cartilage of suitable dimensions taken from the ear or costal cartilage is inserted

through a small incision beneath the skin of the temporal region, in such a manner that when the flap is swung into position, the upper margin of the cartilage will lie on a line just below the palpebral fissure After the graft has become established in its new location, a process which takes about 10 days, a flap pedicled at the outer canthus

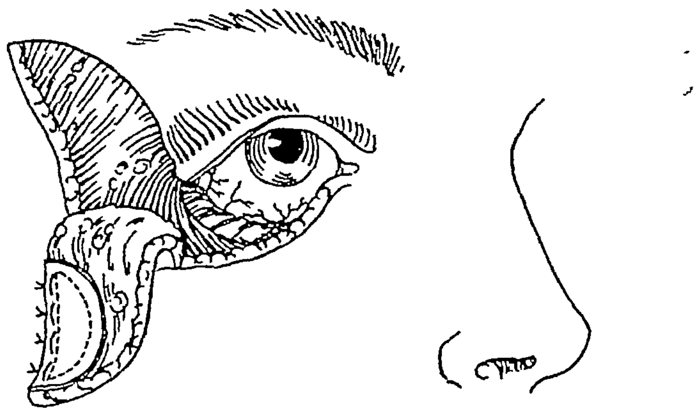


FIG 495 Reconstruction of lower lid by temporal flap lined with cartilage-skin graft from back of auricle (Buedinger and Meller)

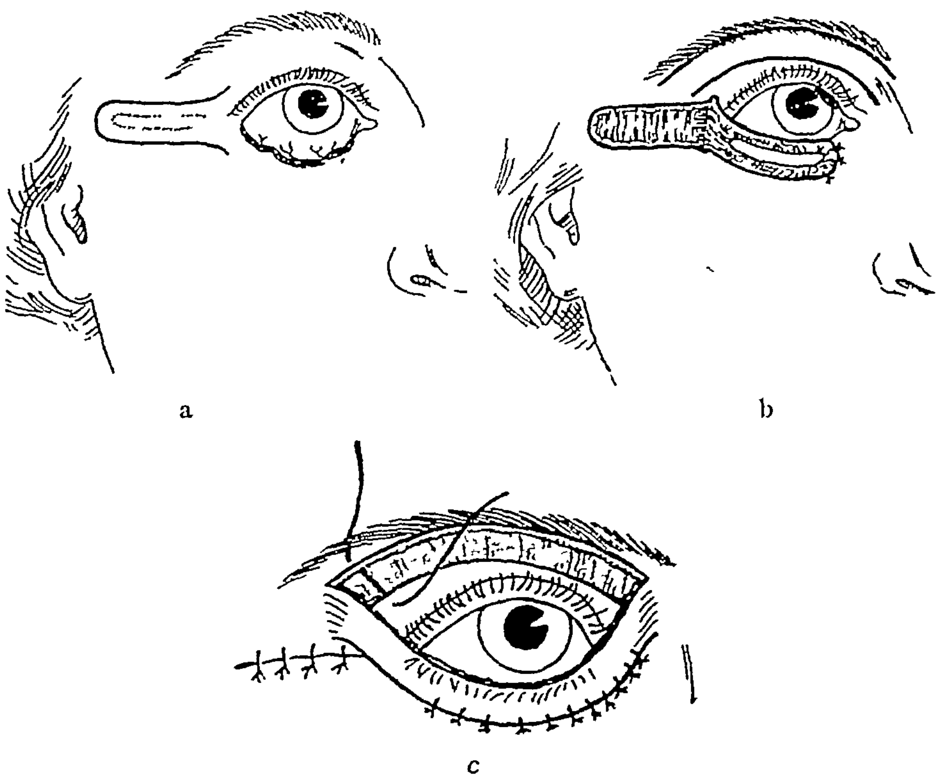


FIG 496 Replacement of total loss of lower lid *a*, strip of cartilage, indicated by dotted line, inserted beneath proposed lining flap *b*, skin-cartilage flap, pedicled at outer canthus, swung medially and fixed to margin of defect Covering flap outlined on upper lid (Gillies) *c*, flap carrying row of eyebrow hair brought down and fixed in place (Tripier)

and comprising skin and the previously implanted cartilage strip is swung medially, skin side inward, and sutured to the remaining conjunctiva The outer raw surface may be covered with a skin graft, an ascending cheek flap, a descending temporal flap, or a double-pedicled flap from the upper lid (78) The secondary wound left after the raising of the flap is closed by direct approximation

FIG 497 Reconstruction of right socket, lower lid, and malar region destroyed by gunshot wound. *A* defect. Deep oblique wound causing cheek and corner of mouth to slump down *B* plan of repair At first stage, scar excised (indicated by shaded area in center diagram) and tissues undermined (indicated by dotted lines) Above and laterally undermining was made superficial to buccal and temporal fascia while below and in front, soft tissues were separated from bone Lower flap made to overlap exposed buccal and temporal fascia and sutured in place At subsequent operation, skin separated from conjunctiva, and temporal flap, previously lined, swung down to replace eyelid *C* result of first operation. *D* result of second operation, wherein temporal flap was used to replace lower lid. *E*, final appearance of patient, showing artificial eye in socket (Medical Dept., U S Army Vol XI)

Figure 497 shows the reconstruction of a lower lid and malar region destroyed by a gunshot wound

Replacement of Eyelashes and Eyebrows

Replacement of Eyelashes A restoration of eyelashes is best effected by means of full thickness hair-bearing grafts, although in some instances hair-bearing flaps may be used to advantage

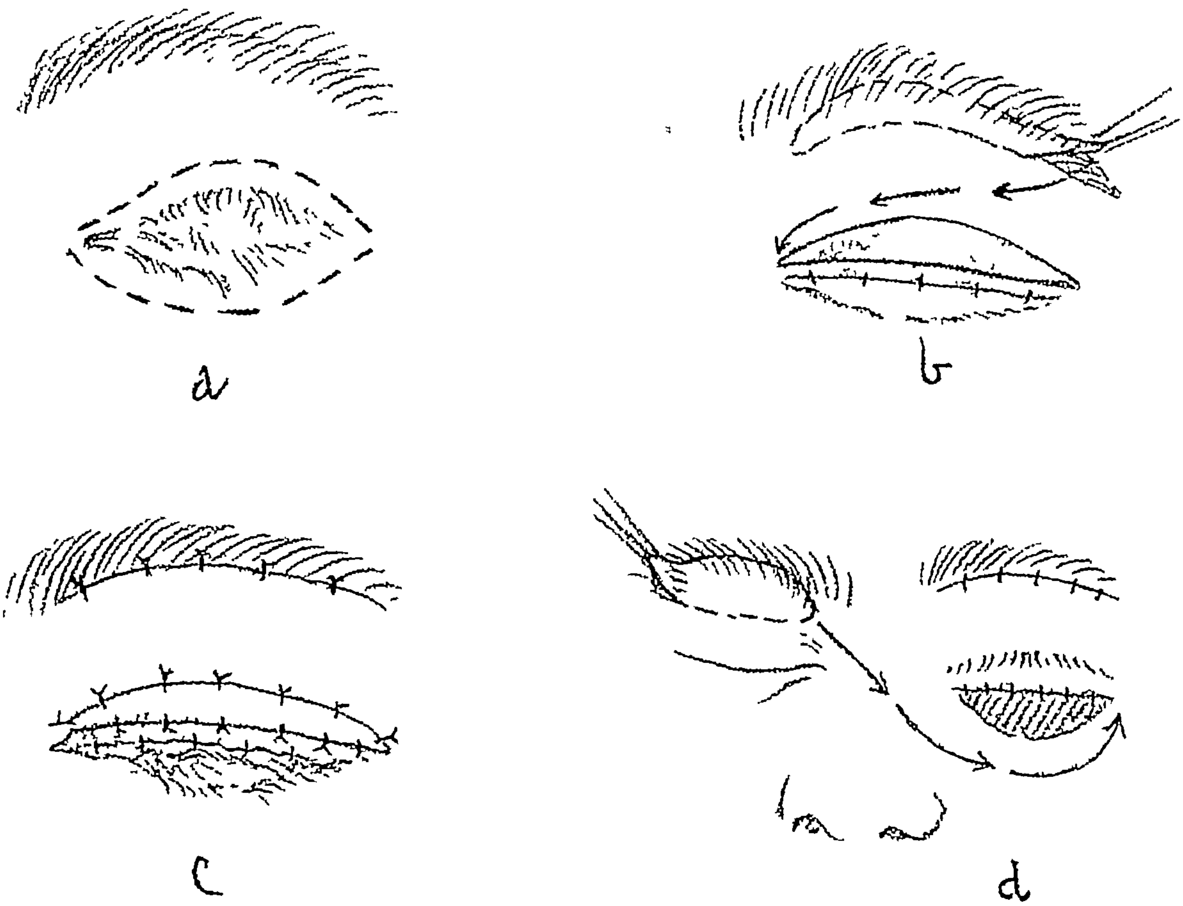


FIG 498 Replacement of eyelashes with hair-bearing graft taken from eyebrow *a*, dotted line indicates line of incision *b*, skin turned down and sutured to adjacent structures Graft carrying row of hair outlined on upper lid *c*, graft raised, reversed, and sutured in place Secondary wound approximated *d*, procedure for replacing lower eyelashes For details, see text (Wheeler)

If grafts are employed, they are taken either from the eyebrow or along the hair line of the retro-auricular region of the scalp For the replacement of the upper eyelashes the technic is as follows (fig 498) An incision is made through the entire length of the lid at a level of 3 to 4 mm above the lid margin, the upper lip of the incision is undermined, reflected downward, and tacked down to the lower lid with paraffined silk sutures, so that the bed will be put on a stretch Scar tissue, if present, is then removed and hemorrhage controlled by pressure After the bed has been thus prepared, an oval graft of a size sufficient to replace the lashes and any adjacent skin loss is dissected from the lower margin of the donor eyebrow The graft is draped over the finger, raw surface up, and all subcutaneous tags are removed, care being taken to avoid injury to the hair follicles When the graft is ready for implantation,

the poles are reversed, so that the hairs will point in the proper direction It is then transferred to the prepared bed, and fixed in place either by direct approximation of its margins to those of the wound, or by means of several fine silk sutures passed through the edges of the wound and tied over the transplant (fig 499) The secondary defect resulting from the removal of the graft is closed by direct approximation of the skin margins. A layer of xeroform gauze large enough to cover both the donor and recipient areas is applied, and over this is placed a pressure dressing (p 124) At the end of a week or 10 days the dressing is carefully peeled off and the sutures removed (85) The same procedure may be employed for the replacement of the eyelashes in the lower lid.

If a flap is to be used to replace the eyelashes, a double-pedicled bridge flap taken from the eyebrow on the side of the defect is swung down into a prepared bed and sutured in place When vascularization is established, the pedicles are cut and the stumps returned to their original sites (78) Figure 496-c illustrates the procedure.

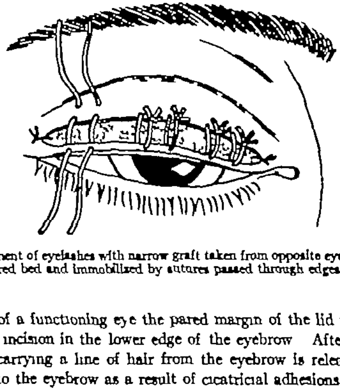


Fig 499 Replacement of eyelashes with narrow graft taken from opposite eyebrow or scalp Graft implanted into prepared bed and immobilized by sutures passed through edges of wound over transplant. (Lexer)

In the absence of a functioning eye the pared margin of the lid may be raised and implanted into an incision in the lower edge of the eyebrow After union has taken place the eyelid carrying a line of hair from the eyebrow is released. If the lid is already attached to the eyebrow as a result of cicatricial adhesions, at the time of its release a rim of hair may be included to take the place of the lost cilia.

Methods have been suggested for the transplantation of the individual hair follicles, but such grafts seldom "take," and the procedure has been generally discarded.

Replacement of Eyebrows Losses of eyebrow tissue are seldom confined to the eyebrow itself, and the method of reconstruction will depend upon the amount of damage to the contiguous tissues. A hair-bearing skin graft can be employed, provided the base offers sufficient nourishment for its survival. In the absence of such a base or in the case of losses requiring more than skin replacement, recourse must be had to flaps taken from some part of the body where a line of hair can be included. If a graft is to be used it is preferably taken from the fellow eyebrow, as this affords the best match (85) (fig 500) If this source is not available, full thickness hair bearing grafts may be procured from the occipital area (57) or the retro-auricular

region (64) of the scalp (fig 501) The technic is the same as that prescribed for any full thickness grafting procedure (p 145) Briefly, a bed is prepared in the recipient eyebrow region by the removal of a wedge of skin and subcutaneous tissue arched to conform to the shape of the normal eyebrow Hemostasis is obtained by pressure or by means of fine ligatures. A pattern of the defect is made and placed on the pre-

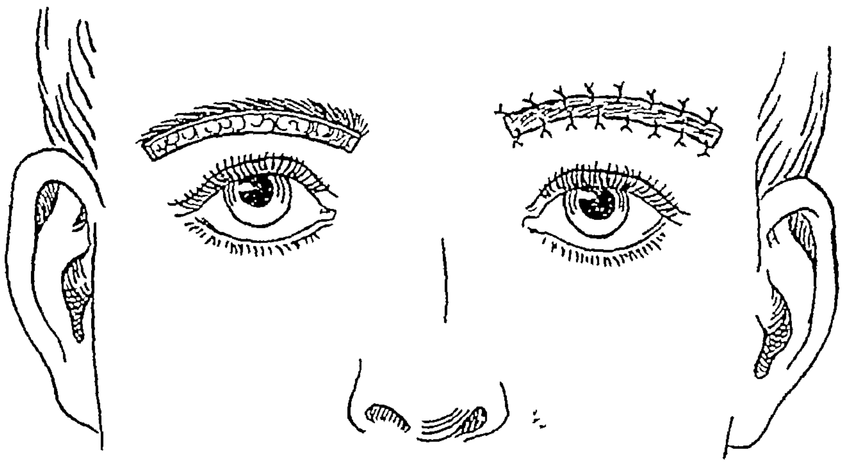


FIG 500 Replacement of eyebrow tissue with hair-bearing graft taken from fellow eyebrow

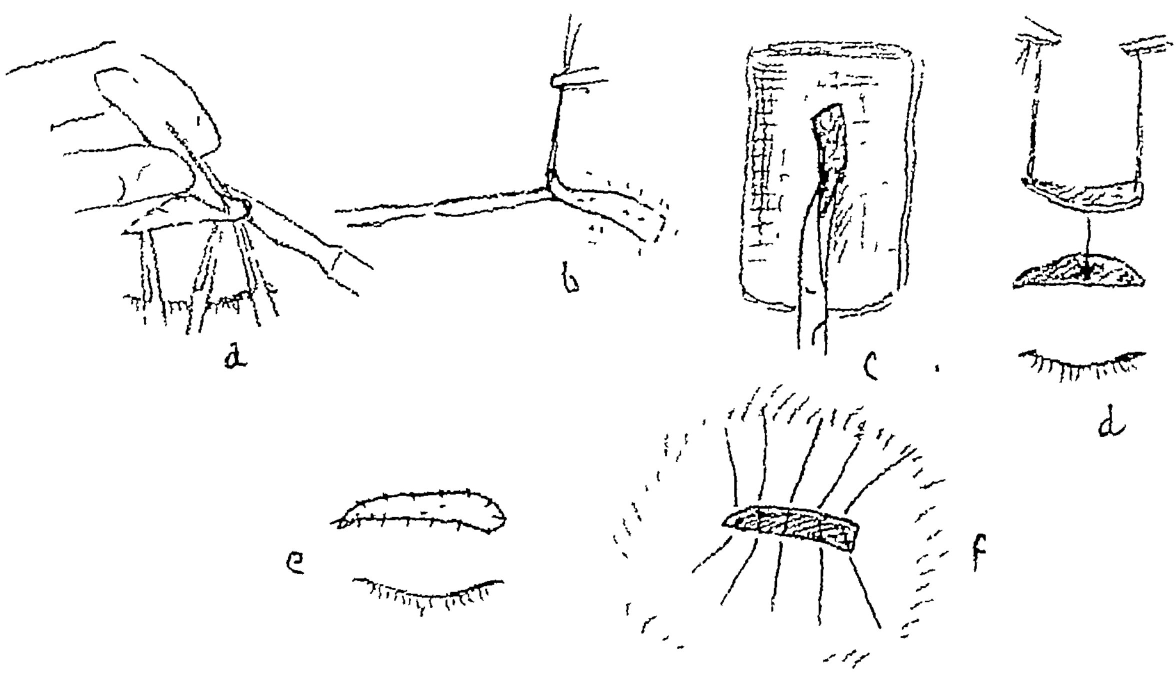


FIG 501 Replacement of eyebrow with hair-bearing graft taken from scalp *a*, scar tissue removed from affected eyebrow, and bed for graft prepared *b*, hair-bearing graft removed from scalp *c*, subcutaneous tissue removed, and graft trimmed to pattern *d*, graft, held by anchor sutures, placed in prepared bed *e*, graft sutured in place Donor wound closed

viously shaved donor area in such a manner that the hair will assume the proper direction when transplanted The transplant is excised, and the donor area is closed by direct approximation The graft is trimmed, fitted into the prepared bed, and secured in place with silk sutures, the knots being tied on the side of the host The grafted area is covered with a layer of xeroform gauze over which a pressure dressing

is applied (p 124) On the eighth or tenth day following operation the dressing is removed, the sutures are taken out, and a new pressure dressing applied for another week.

The defect may also be repaired with a flap taken from the opposite eyebrow A bed about 10 mm wide and of the required length is prepared in the usual manner (p 842) for the reception of the flap The donor eyebrow having been shaved a flap of the proper dimensions is outlined along its lower half, the pedicle lying at the glabella. The flap, consisting of skin and subcutaneous tissue, is dissected up, rotated into the previously prepared bed, and sutured in place (fig 502) A light dressing is applied. Eight or 10 days later, when vascularization will have taken place, the sutures are removed, the pedicle cut, and the stump returned to its former site.

Flaps may likewise be taken from the hair line of the temporal region, the pedicle lying below and containing the temporal artery These flaps are particularly applicable for women, as the scar can be concealed by the coiffure

Finally a temporal artery flap after the plan of Monks and Esser (25, 63) can often be used to advantage (fig 136) The temporal artery with its accompanying veins,

FIG 502 Replacement of eyebrow hair by flap taken from fellow eyebrow

nerves, and lymphatics held together in a core of connective tissue is dissected up, and from the lower extremity of the wound a subcutaneous tunnel is made extending to a prepared bed in the eyebrow Adjoining the upper end of the incision an island of hair bearing skin pedicled on the dissected core of vessels is raised, passed through the subcutaneous tunnel, and fixed into the defect. The incision made for the exposal of the blood vessel is then closed by direct approximation.

Lexer carried what he termed a 'caterpillar" or "creeping" flap from the occipital region to the defective eyebrow, in the following manner A flap about 2 cm. in width, pedicled above the ear, is cut from the occipital scalp The flap is folded *on itself* raw surface to raw surface, and its free end sutured in place at a site near the pedicle. The secondary scalp wound is closed by direct approximation. In a few weeks the original pedicle is cut and the flap is opened up and extended into a bed prepared nearer to the defect. The above procedure is repeated until the flap is brought to its final destination.

If a flap from the neighborhood is unavailable, the defect may be filled with a hair bearing flap from some distant part of the body, the hand being used as a carrier

BLEPHAROPTOSIS

Ptosis of the eyelid occurs as a result of either a paralysis or an underdevelopment of the levator muscle and ranges in severity from a slight drooping to a complete prolapse In the latter case the lid hangs over the eye, relaxed, motionless, and devoid of wrinkles The patient, in order to see, either contracts the epicranius muscle and tilts his head backward, so as to bring the pupil into the palpebral fissure, or lifts the lid with the finger to remove it from the field of vision The condition may be congenital or acquired The congenital form is the most common, is usually bilateral, and is due to an underdevelopment or absence of the levator palpebrae superioris muscle The acquired variety is more often unilateral and is the result of injury to the levator tendon or of paralysis of the oculomotor nerve Ptosis may also be simulated by the action of scars binding down the lid or by inflammatory and neoplastic conditions which make it too heavy to be lifted by the levator muscle Since in these instances there is no associated muscular paralysis, the condition can be relieved by removal of the pathologic tissue and repair of the remaining defect in accordance with one of the methods outlined under "Repair Following Loss of Tissue" (p 841)

Many operations have been devised for the relief of ptosis, but none of these is completely satisfactory, since no surgical substitute can perfectly compensate for the complicated structure and function of the paralyzed levator palpebrae muscle In this connection Beard (8) remarks "All who have had much experience in this branch of ophthalmic surgery will agree that the results of ptosis operations, taken all in all, are far from brilliant " The earliest procedures contemplated an elevation of the eyelid by a shortening of its vertical length, through the excision of an oval section of skin or of a strip of the orbicularis oculi muscle (36) These attempts proved ineffectual, however, inasmuch as they resulted in a condition of lagophthalmos, exposing the cornea to injury, and in time the tissues stretched and gave rise to a recurrence of the deformity Therefore, today such measures are resorted to only as supplements to other operations

The operative procedures in use at present may be grouped as follows (1) Those designed to alter the insertion of the levator tendon or to shorten the muscle in such a way as to make it act to a better advantage (2) Those planned to compensate in some measure for the deficiency of the levator by the substitution of other muscles which operate in a similar manner but are activated by different nerves: (a) those aimed at the transfer of the function of the levator to the epicranius (b) those directed toward the transfer of the function of the levator to the superior rectus There is no single operation which will meet all problems The method or combination of methods best suited to the particular case will depend upon the amount of contractile power, if any, remaining in the levator palpebrae superioris This function can be tested in the following manner The patient is asked to close his eyes, and pressure is then exerted on the lid against the superior margin of the orbit, so that the action of the epicranius will be nullified The degree of lid elevation that can now be attained will be an index of the activity of the levator.

In cases where the levator, though weakened, still possesses some contractile power, it is often possible to enhance its action on the lid either by advancing its insertion or by resecting a portion of its substance But if the levator is entirely inactive, such procedures would obviously be ineffectual Under these circumstances it is necessary to call in the aid of the accessory muscles for the purpose of raising the lid In view

of the clearly observable fact that when the forehead is wrinkled, the eyebrows are lifted and the lids are raised by a tightening and drawing up of the lid tissue, the first operative attempts to relieve blepharoptosis consisted in attaching the fibers of the paralyzed levator to the epicranius (21) A number of methods have been devised for the formation of an artificial tendon between the epicranius muscle and the deep tissues of the lid by means of (1) threads, (2) skin flaps, (3) muscle strips, and (4) fascia lata While these procedures are successful in raising the lid, they present certain objectionable features. They fail to restore the intimate motor relationship between the eyelid and eyeball inasmuch as the direction of the pull is upward and forward instead of upward and backward—for example, on contraction of the epicranius the border of the lid tends to be pulled forward and away from the eyeball as the lid travels upward, they produce considerable scarring, and in the case of unilateral ptosis they give rise to peculiar facial grimaces simultaneous with palpebral function. In an effort to overcome these drawbacks attention was directed toward the utilization of the superior rectus muscle

Motais (66) and Parinaud (70) conceived the idea of substituting the action of the tendon of the superior rectus muscle for that of the levator This proved to be an excellent procedure, in that it brought about a more normal relationship between the movements of the paralyzed lid and those of the eyeball and was found to be no more difficult of execution. It is still the method of choice in cases of bilateral ptosis in the presence of normal superior rectus muscles. The operation has, however, several disadvantages. The tendon attached to the tarsus is likely to give way or produce a tenting effect because of its small size, in unilateral ptosis the weakening of the superior rectus by reason of its division tends to produce diplopia, during sleep the eye is apt to remain open, and thus the cornea and conjunctiva are endangered through exposure and finally in congenital ptosis the superior rectus, as a rule, is insufficiently developed to render its use practicable.

Treatment

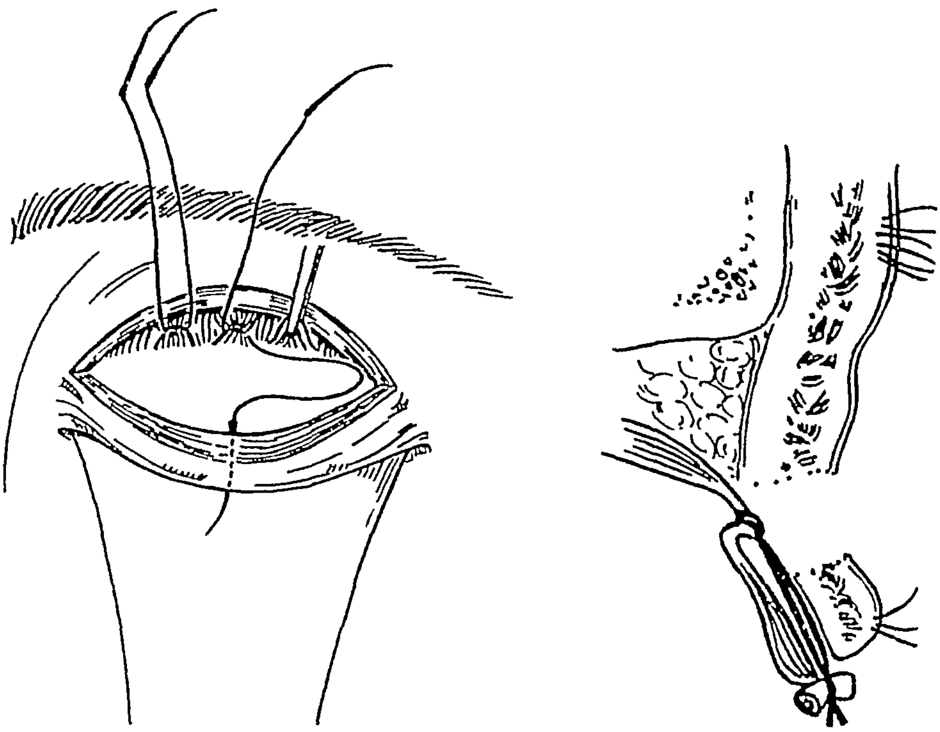
Treatment should be instituted as soon as the condition becomes permanently established, especially in the case of children in whom the ptosis may result in faulty posture due to hyperextension of the head and spine in an effort to see If, for some reason, operation must be delayed, specially constructed eyeglasses equipped with spring attachments for the elevation of the lid may be worn during the interval.

The instruments required for ptosis operations include a horn or metal spatula, scalpels, scissors, dissecting forceps, a squint hook, a dural hook, fixation forceps, hemostats needles, needle holders and suture material. Local anesthesia is employed when possible, in order that the patient s co-operation may be obtained. Block anesthesia of the frontal, infratrochlear, and lacrimal nerves is preferable to direct infiltration, as the latter method causes a swelling of the lids which interferes with their movement and renders difficult an accurate estimation of the degree of correction necessary

Operations Designed to Correct Condition by Altering Insertion of, or by Shortening Levator Tendon

Examples of this type of operation are those of Eversbusch (27), de Lapersonne (55), and Blaskovics (13)

Eversbusch's (27) Operation. In this operation the levator muscle is folded and its insertion advanced to a site nearer the free border of the lid as follows· A transverse incision is made through the center of the lid down to the tarsus (fig. 503) The margins of the incision are undermined in the plane beneath the orbicularis muscle for a distance sufficient to expose the upper border of the tarsus and the levator muscle. A double-armed suture is looped around the central bundle of muscle fibers of the levator tendon, and two similar loops are passed around the muscle on each side of the central suture. The two ends of each loop are carried down between the skin and tarsus and brought out through the intermarginal space posterior to the eyelashes, where they are tied over glass beads When the ends are drawn taut, the tendon of



a b

FIG 503 Everbusch operation for advancement of levator muscle to site nearer free border of lid *a*, transverse incision made through center of lid, and margins undermined in plane beneath orbicularis muscle Sutures looped around levator tendon and brought out through intermarginal incision Sutures tied under tension, to draw tendon of levator down to lower level *b*, sectional view, showing folding of muscle on itself when suture is drawn taut

the levator is automatically drawn down to a lower level The skin wound is carefully approximated More permanent results are obtainable by the excision of a portion of the tendon, as illustrated in the operation devised by de Lapersonne

De Lapersonne's (55) Operation. A transverse incision through skin and muscle is made 4 to 5 mm above the free border of the lid throughout its entire length The tissues are undermined to expose the tarsal cartilage, the orbital fascia, and the insertion of the levator palpebrae. In the orbital fascia on either side of the tendon two small incisions are made, and through these openings a squint hook is passed under the tendon Through the substance of each side of the tendon thus brought into view a double-armed suture is passed, the loops being made to lie on its posterior surface The level at which the stitches are to be passed is determined by the amount of shortening desired The greater the elevation necessary, the further back the posi-

tion of the sutures. The needle of each suture limb is then made to take a bite of the anterior surface of the tarsus, after which the muscle is severed close to its insertion and the sutures are tied. The tendon is thus reattached lower down on the anterior surface of the tarsus where it can function to better advantage. The initial incision is carefully approximated (fig 504)

Blaskovics' Operation. Blaskovics (13) operates in much the same manner, but in addition to shortening the levator he resects a portion of the tarsus and also creates a normal-appearing fold in the eyelid. The steps of the operation are as follows The upper lid is everted by means of a lid holder, and the operative field is anesthetized by an injection under the conjunctiva of 2 cc. of a procain epinephrin solution. With a scalpel an incision is made through the conjunctiva along the convex border of the tarsus, care being taken to avoid damage to the underlying levator muscle. Three interrupted sutures are introduced into the proximal lip of the incision in the con-

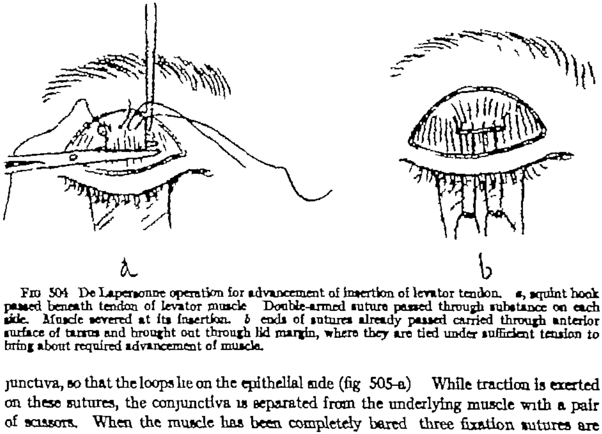


Fig 504 De Lapersonne operation for advancement of insertion of levator tendon. *a*, squint hook passed beneath tendon of levator muscle Double-armed suture passed through substance on each side. Muscle severed at its insertion. *b* ends of sutures already passed carried through anterior surface of tarsus and brought out through lid margin, where they are tied under sufficient tension to bring about required advancement of muscle.

junctiva, so that the loops lie on the epithelial side (fig 505-a) While traction is exerted on these sutures, the conjunctiva is separated from the underlying muscle with a pair of scissors. When the muscle has been completely bared three fixation sutures are inserted at equidistant points in its substance (fig 505-b), and the muscle is cut across distal to them Traction is now exerted on the fixation sutures, and with a scalpel the muscle is freed on both sides and drawn out of the orbit (fig 505-c) The previously passed conjunctival sutures are now passed through the muscle from behind forward, the point of emergence being determined by the amount of shortening desired. The distal extremity of the levator through which the fixation sutures have been passed is then resected at a level just distal to the conjunctival sutures (fig 505-d) The fold-forming sutures are now passed as follows Traction is exerted on the conjunctival sutures to pull the muscle forward (fig 505-f) and 3 mattress-sutures are passed through its substance. Blaskovics warns against placing them too high in the muscle. Before these latter sutures are passed through the skin, a portion of the tarsus is excised. To

accomplish this the lid is everted, a horizontal incision made along the center of the tarsus, and a portion of the tarsal plate resected The 3 mattress-sutures are now passed through the lid skin from behind forward at the height of the proposed fold (fig 505-g) and left untied The stump of the levator is then fixed to the lid by carrying

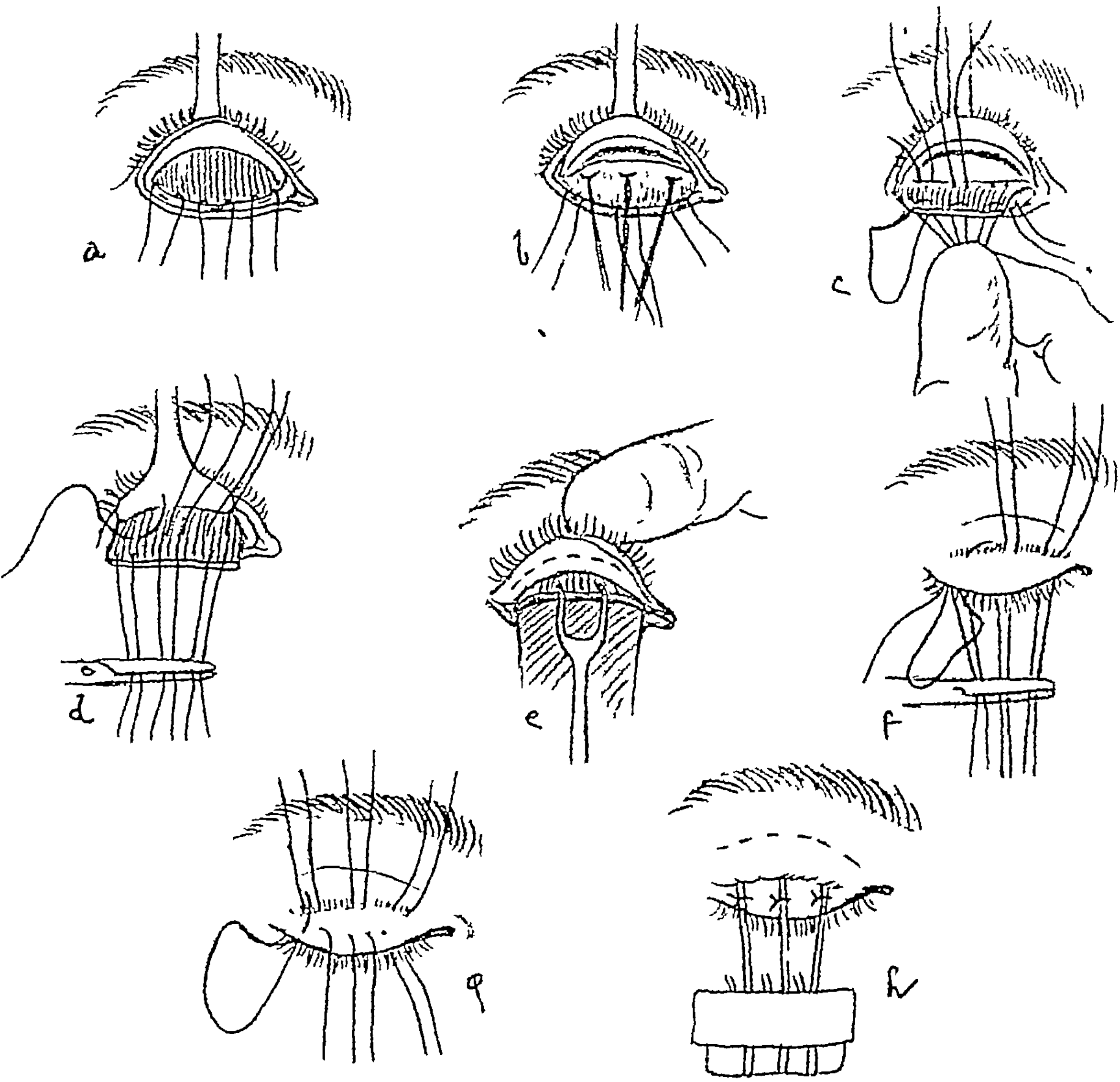


FIG 505 Blaskovics operation for ptosis a, lid everted, and incision made in conjunctiva along border of tarsus Three sutures introduced through proximal lip b, levator muscle bared, 3 fixation sutures inserted, and muscle incised c, muscle drawn out of orbit, and previously placed conjunctival sutures passed through muscle from behind forward d, fold-forming sutures placed Three mattress sutures passed through muscle substance. e, levator cut distal to conjunctival sutures Dotted line indicates portion of tarsal plate to be excised f, fold-forming sutures passed through lid g, stump of levator fixed to lid by carrying conjunctival sutures through skin h, fold-forming sutures attached to cheek with adhesive

the conjunctival sutures through the skin and tying them over rubber plates The fold-forming sutures are attached to the cheek with a strip of adhesive under slight tension (fig 505-h) and left in place for 24 hours, at which time they are cut and the adhesive removed The eye is then protected by a Fuchs shield All sutures are removed on the sixth day

Operations Designed to Transfer Function of Levator Palpebrae to Epicranius Muscle by Creation of Artificial Tendon between Epicranius and Deep Tissues of Lid

(1) **By Threads.** Attempts have been made to relieve blepharoptosis by the attachment of the levator palpebrae muscle to the epicranius by means of threads. These procedures were devised before the advent of asepsis, and their advocates depended upon infection for the formation of cicatricial bands which would maintain the elevation of the lid (67, 90) But with the present-day aseptic technic the cicatricial bands thus created are negligible, and the operations find little favor However, three of these procedures will be described below

Pagenstecher's (67) *Operation* (fig 506) One needle of a double-armed suture is entered 2 mm above the free margin of the lid and about 7 mm from the inner canthus, and is carried up subcutaneously to emerge just above the eyebrow The second needle is passed parallel to and a few millimeters from, the first There is thus formed

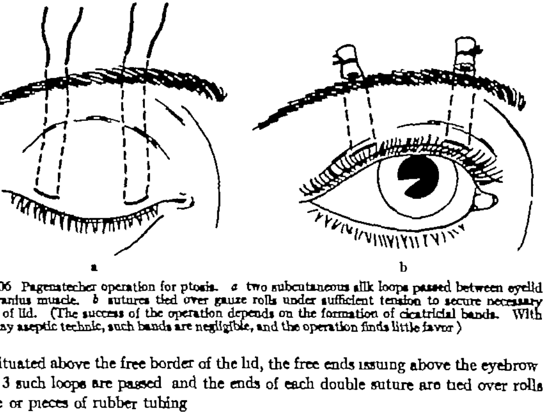


FIG 506 Pagenstecher operation for ptosis. *a* two subcutaneous silk loops passed between eyelid and epicranius muscle. *b* sutures tied over gauze rolls under sufficient tension to secure necessary elevation of lid. (The success of the operation depends on the formation of cicatricial bands. With present-day aseptic technic, such bands are negligible, and the operation finds little favor)

a loop situated above the free border of the lid, the free ends issuing above the eyebrow Two or 3 such loops are passed and the ends of each double suture are tied over rolls of gauze or pieces of rubber tubing

Hess' Operation Hess (39) modified Pagenstecher's operation by undermining the skin and displacing it upward in the hope that adhesions would form between the raw surfaces and maintain the lid in its normal position, but he met with no better success. His technic is as follows (fig 507) An incision is made through the center of the eyebrow traversing its entire length, and the skin is undermined to the free border of the lid. Three loops are passed at equidistant points One needle of a double armed suture is entered through the skin close to the margin of the lid and is forced up between the skin and the orbicularis muscle to the upper margin of the wound, where it is made to penetrate the muscle deeply It is then brought out through the skin at a point about 15 mm above the eyebrow The other needle is entered 5 mm. to one side of the first and is made to follow a parallel course The 2 remaining sutures

are passed in a similar manner. The free ends projecting above the eyebrow are drawn tightly, until the desired elevation has been produced, and the ends of each loop are then tied over small rubber plates The wound in the brow is approximated with horsehair. The superficial sutures are removed in 3 or 4 days, and the deep sutures in 10 to 14 days

Elschnig's Operation. Elschnig (23) modified Hess' operation in the following manner (fig 508): A section of eyelid skin is pinched up at a site where it will create the impression of a natural fold Below and parallel to this fold an incision is made through which the skin is undermined to the eyebrow Three loops are then passed through the margins of the wound and made to emerge above the eyebrow The first loop is placed 6 mm from the inner canthus, the second just lateral to the center of the lid, and the third about 6 mm from the outer canthus Each suture is passed as follows (fig 508-I). One needle of the double-armed suture is inserted in the skin 3 mm below the lower margin of the wound, passed underneath the detached skin,

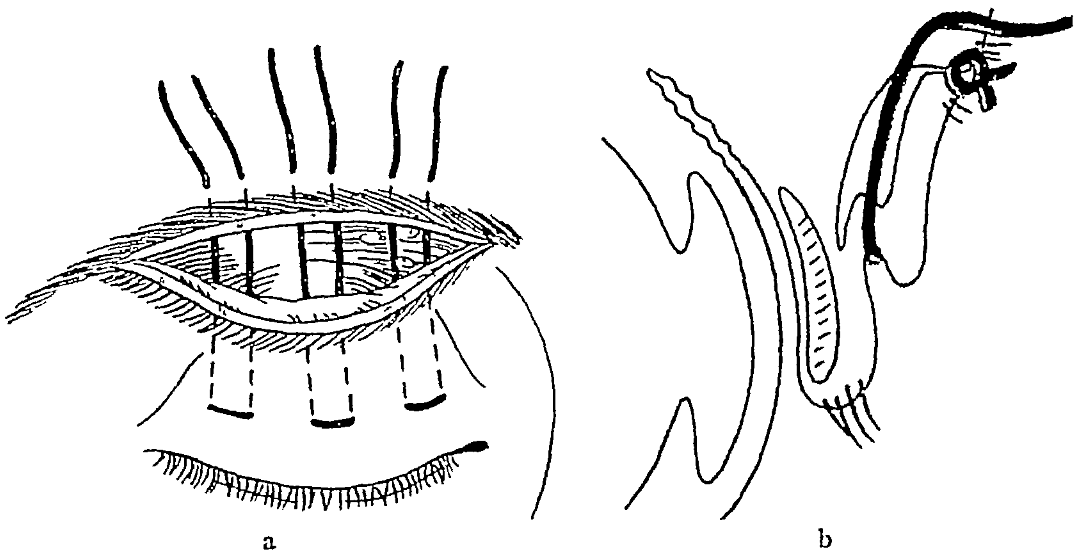
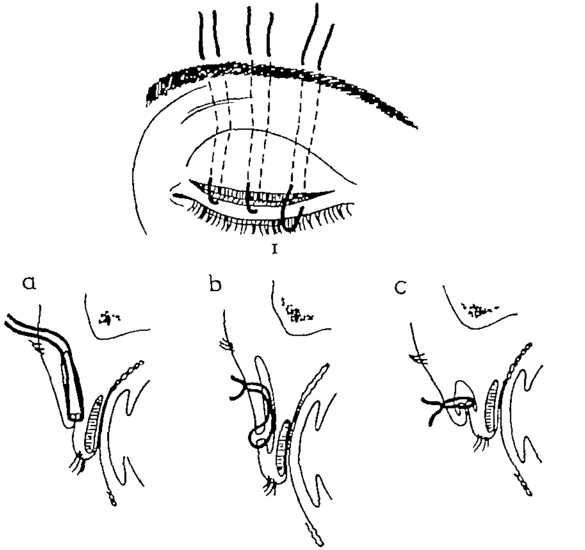


FIG 507 Hess operation for ptosis *a*, incision made through center of eyebrow, and skin of lid undermined to its free border Three silk loops passed and tied under sufficient tension to obtain desired elevation of lid *b*, sagittal view, showing effect of tightening sutures (This operation has the same objection as that of Pagenstecher)

and made to emerge above the eyebrow. The second needle is passed through the skin of the upper rim of the wound and made to issue above the eyebrow on a line with the first and 4 mm distal to it After the 3 sutures have been passed, their action is tested If the desired fold and amount of shortening have been obtained, the ends are tied, otherwise, supplementary mattress-sutures are passed alongside the 3 sutures previously placed These are carried through the upper and lower edges of the wound and beneath the undermined skin as before, but are made to emerge below the eyebrow instead of above it (fig 508-II). These latter sutures are also tested, and if the lid is still too long, a third series of loops may be passed, the ends passing out on the eyelid skin just above the margin of the wound After the proper adjustment has been made, the sutures are tied in the reverse order of their emplacement (fig 508-II) The wound is then covered with a vaselin dressing, and a bandage is applied

(2) **By Skin Flaps.** As an alternative to the use of threads for the attachment

of the ptosed eyelid to the epicranius, flaps of eyelid skin denuded of epithelium have been employed but the results are uncertain, because of the tendency of the skin to stretch, and the remaining scars are unsightly Examples of this type of operation are those of Panas, Hunt, Lemberg and Gifford. Only the last-mentioned will be described.



I

a b c

II

FIG 508. Elschnig operation for ptosis. *I* incision made just below proposed site of fold, and skin undermined to eyebrow Three subcutaneous loops passed. *II* sectional view *a* suture tightened to elevate eyelid and form lid fold *b* supplementary mattress-sutures passed below eyebrow *c* result of tightening latter suture For details, see text.

Gifford's (31) *Operation* (fig 509) On each side of the ptosed lid a narrow flap of skin is passed subcutaneously and fixed to the epicranius, thus A longitudinal incision (1–2) is made 6 mm. above the margin of the upper lid extending to within 6 mm. of the outer and inner canthi Another somewhat longer incision (3–4) is then made about 5 mm. above the first and parallel to it. The long strip of skin thus marked out (1–2) (3–4) is divided in the middle (5–6) to outline 2 flaps which are freed from the tarsus. At the site of the pedicles 2 subcutaneous channels are made, opening just above the eyebrow The flaps are denuded of epidermis, and double-armed sutures are introduced at their free ends, the loops lying on their under

surfaces The needles are then passed through the subcutaneous tunnels and made to emerge through the incisions above the eyebrow. By means of traction exerted on the sutures the flaps are drawn through the tunnels and the lid elevated to the desired level The needles are then passed through the upper lip of the incision, and

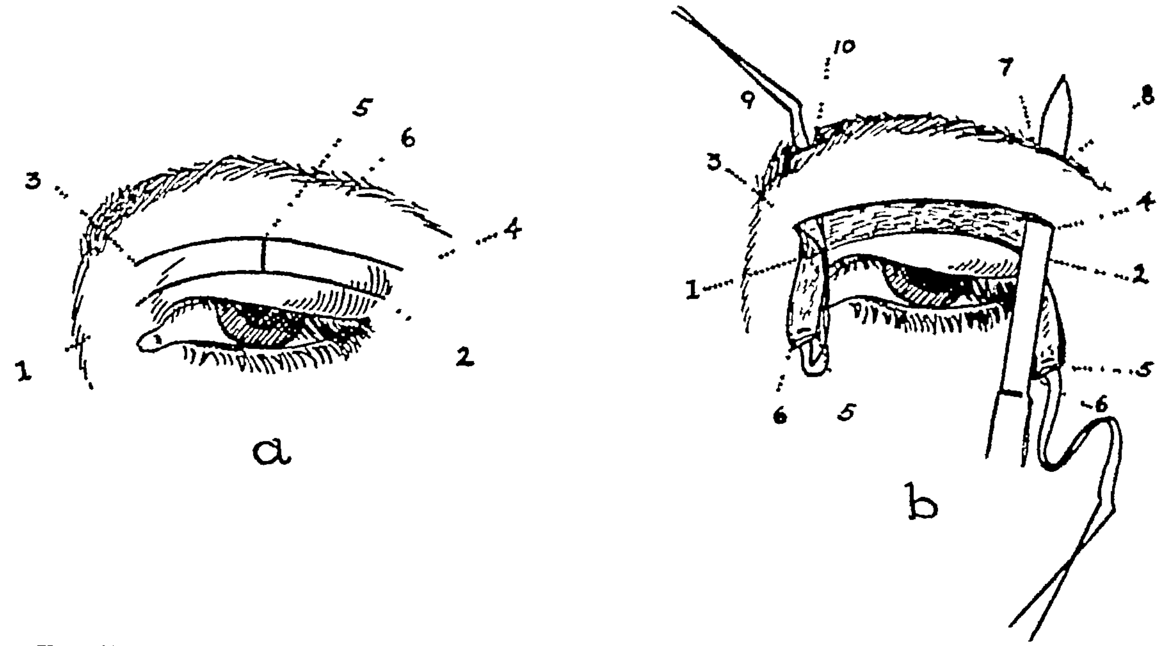


FIG 509 Attachment of eyelid to epicranius by use of skin flaps *a*, two parallel incisions *1–2* and *3–4* made above lid margin and divided by vertical incision *5–6* *b*, surface epithelium removed, and strips drawn through subcutaneous tunnels *7–8* and *9–10* For details, see text (Gifford-Machek) (The results of the operation are uncertain, the skin tends to stretch, and the remaining scars are unsightly)

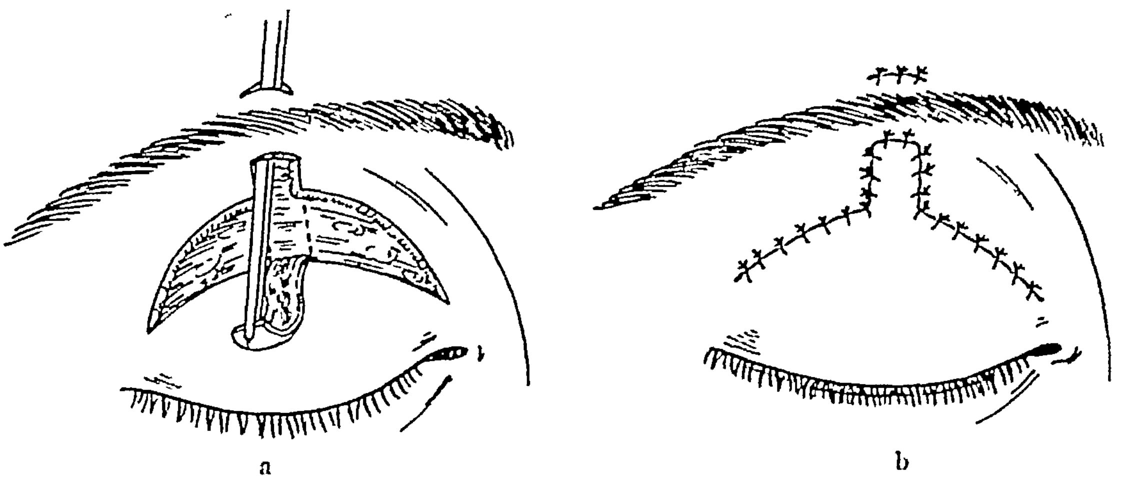


FIG 510 Tansley-Hunt operation for ptosis *a*, crescentic section of skin removed from lid, flap of skin pedicled below being left intact at center *b*, flap de-epithelized, drawn through subcutaneous tunnel beneath eyebrow, and sutured in place under sufficient tension to overcome ptosis (The results are temporary, and the operation finds little favor)

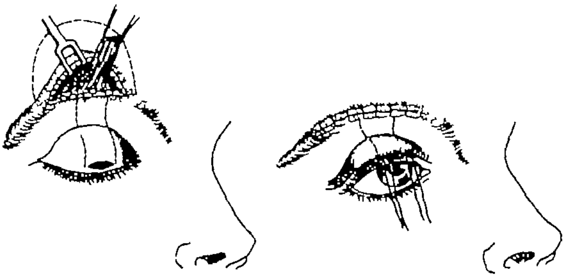
the sutures are tied An ordinary dressing is applied and removed, together with the sutures, in 5 or 6 days

An operation based upon the same principle is that of Tansley-Hunt Figure 510 is self-explanatory

(3) **By Muscle Flaps** Elevation of the lid by means of muscle flaps contemplates

the direct transplantation of a flap taken from the epicranius muscle into a pocket formed between the tarsus and the orbicularis oculi, or the transplantation of a flap from the orbicularis oculi into the epicranius. Theoretically, the use of muscle flaps for the transfer of the action of the epicranius to the levator would seem the ideal procedure, but practically such flaps have no advantage over fascia lata slings, inasmuch as they are likely to be too weak to carry out their intended function and are often torn off. There is also the danger of hernia of the areolar fat if they are passed through an incision in the tarso-orbital fascia. The principle is exemplified in the operations of Esser, Reese, Roberts, and Ferguson. The first 3 of these will be described below.

Esser's Operation. Esser (25) operates as follows (fig. 511). A horizontal incision is made along the middle third of the eyebrow and through this opening the skin of the forehead is undermined and retracted. A flap of epicranius muscle 1 to 2 cm. wide, pedicled below at the level of the eyebrow incision, is raised, and 2 silk sutures



a b

FIG. 511. Elevation of lid by use of muscle flap taken from epicranius. *a*, horizontal incision made along middle third of eyebrow. Dotted line indicates amount of undermining. Flap of epicranius muscle raised, and 2 sutures passed through its free end. Through incision just above lid margin, subcutaneous canal constructed, as indicated by dotted lines. *b*, muscle drawn through canal and sutured under sufficient tension to obtain necessary elevation. Wound in eyebrow closed. (Esser.) (*For objectionable features, see text.*)

are passed through its free extremity. A short horizontal incision is then made through the skin just above the center of the upper lid margin. By blunt dissection a tunnel is constructed between the 2 incisions. A forceps is inserted in the lower incision and made to grasp the sutures attached to the free end of the muscle flap. The flap is drawn through the tunnel and made to emerge at the lower opening in the lid, where it is fastened subcutaneously to the underlying structures after the proper amount of elevation has been obtained. The remaining wounds are sutured.

Reese's Operation. Reese (71) utilizes a flap taken from the orbicularis oculi muscle, as follows. A transverse arched incision is made in the skin of the lid throughout its length about 6 mm. from the lid margin, and the lips of the wound are undermined for several millimeters. A strip of orbicularis muscle 10 mm. wide is separated from the tarsus, except at its central portion where it is left attached. On either side of the attached portion a subcutaneous tunnel is constructed to the eyebrow. Through

these tunnels the ends of the muscle are drawn and made to emerge through the openings above the eyebrow. When sufficient tension has been exerted to bring the lid to its

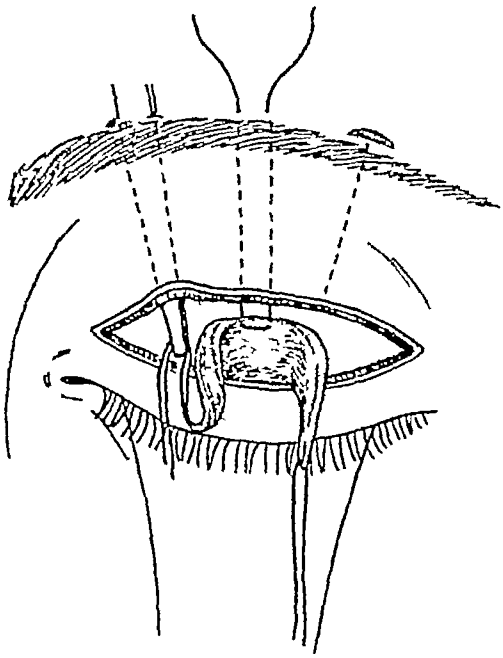


FIG 512 Elevation of lid by use of muscle flap taken from orbicularis oculi Through transverse incision above lid margin, strip of orbicularis oculi muscle separated, except at its central portion Ends of muscle drawn through subcutaneous tunnels and fixed under sufficient tension to raise lid to required height (Reese)

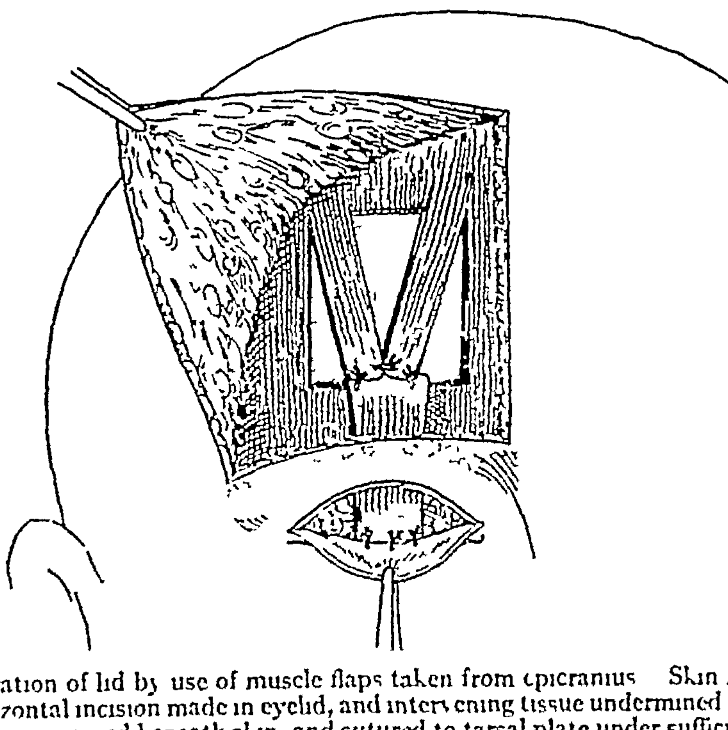


FIG 513 Elevation of lid by use of muscle flaps taken from epicranius Skin flap raised, to expose epicranius Horizontal incision made in eyelid, and intervening tissue undermined Muscle flap turned down from epicranius, passed beneath skin, and sutured to tarsal plate under sufficient tension to obtain necessary elevation Pedicle of flap reinforced by two additional flaps from epicranius (Roberts) (For objections to this procedure, see text)

proper position, the ends of the muscle are fixed in place by means of sutures. Figure 512 is self-explanatory.

Roberts' Operation Roberts (72) operates in the following manner (fig 513) A triangular skin flap is raised from the forehead to expose the epicranius muscle. Just beneath the upper orbital margin a skin incision is made along the entire extent of the lid. Through this incision the skin is undermined to expose the tarsal plate Between the two wounds a tunnel about 5 cm. wide is constructed beneath the orbicularis muscle. A flap is then outlined on the epicranius muscle about 1.5 cm. wide and 3 to 4 cm. long, pedicled above the eyebrow This flap is turned downward, thrust through the tunnel, and tested until the proper amount of elevation has been attained, after which it is attached to the edge of the tarsal plate by means of 3 fine silk sutures. From the epicranius muscle 2 additional flaps, pedicled above, are raised, drawn together, and fixed to the pedicle of the middle muscle flap by the use of 3 mattress-sutures. The 3 muscle flaps will now assume the form of a letter Y, as indicated in the diagram Finally, the skin flap is sutured back into place. The functional results of this operation are no better than those of the procedures already described, and it has the additional objection of producing extensive scarring

(4) **By Fascia Lata.** The most satisfactory method of suspension is the attachment of the tarsal plate to the epicranius muscle by means of strips of autogenous fascia lata. The technic is as follows With the eyelid drawn down by means of 2 silk traction sutures passed through its substance, a horizontal incision 1 cm. long is made through the skin at a point about 12 to 15 mm. above the center of the eyebrow Two similar incisions are made in the eyelid at points just above the outer and inner thirds of the tarsal border Through the uppermost incision a small Reverdin needle is introduced, made to take a bite of the epicranius muscle, and carried obliquely downward through the tissues to emerge through the inner eyelid incision, where it is threaded with a strip of fascia lata about 3 mm wide and drawn back through the original opening The ends of the fascia now protrude through both incisions. The empty needle is then introduced through the opening in the outer third of the lid, is carried transversely across the lid, engaging the substance of the tarsal plate, and is made to emerge through the incision on the inner side of the lid, where it is threaded with the fascia protruding through the opening and is withdrawn. The needle is again introduced through the original incision above the eyebrow, carried obliquely downward, and made to issue through the opening in the outer third of the lid, threaded with the fascia and again withdrawn. Traction is exerted on the 2 ends of the fascia strip now projecting through the incision above the eyebrow, and when the lid margin assumes the proper level, the fascia is knotted and fixed to the epicranius with a silk suture Finally, the wounds of entry and exit of the needle are closed (9)

Wiener's Operation Wiener (88) operates essentially as follows A skin incision 1 cm long is made in the center of the upper lid just above the lid margin. Through this opening the tarsus is exposed Two incisions of similar length are then made above the eyebrow, one on either side of the central incision, exposing the epicranius. A Reverdin needle is passed subcutaneously from one of the openings above the brow and is made to appear through the incision above the margin of the lid. The needle is threaded with a strip of fascia lata, drawn up, and the end of the strip sutured to the epicranius The needle is then passed from the other incision above the brow, made to emerge through the opening in the lid threaded with the protruding end of the strip, and withdrawn Traction is exerted on the end until the ptosis is overcome.

The fascia is then secured to the tarsus below and to the epicranius above with 2 buried silk sutures The 3 small secondary wounds are closed with fine silk (fig. 514)

Lexer's Operation Lexer (57) employed 2 strips of fascia lata as follows: Two incisions each about 1 cm. long are made just above the eyebrow, one at the junction

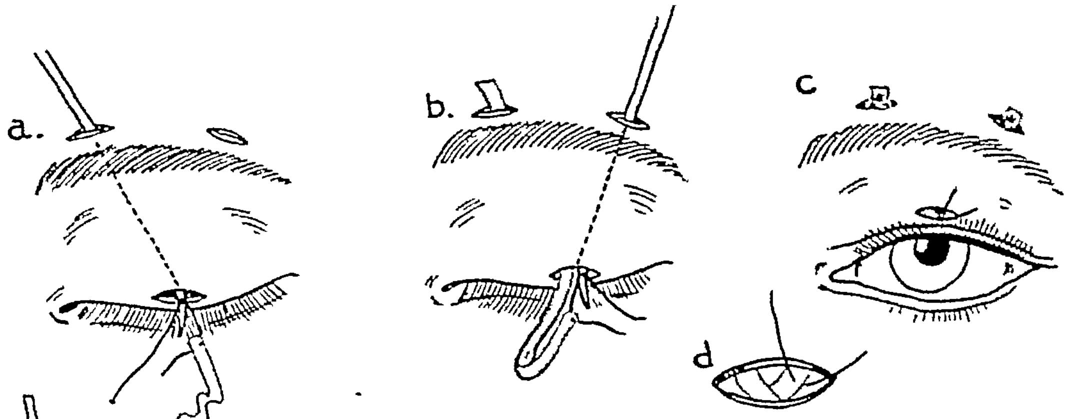


FIG 514 Elevation of lid by use of fascia lata strips *a*, incision made in lid margin, to expose tarsus Two incisions made above eyebrow, to expose epicranius Needle passed from upper to lower incision, threaded with strip of fascia lata *b*, end of strip drawn up and sutured to epicranius Other end drawn through in similar manner *c*, traction exerted on ends, to obtain required elevation, and ends fixed in place Fascia loop secured to tarsus below *d*, shows method of fixing fascia to tarsal plate. (Wiener)

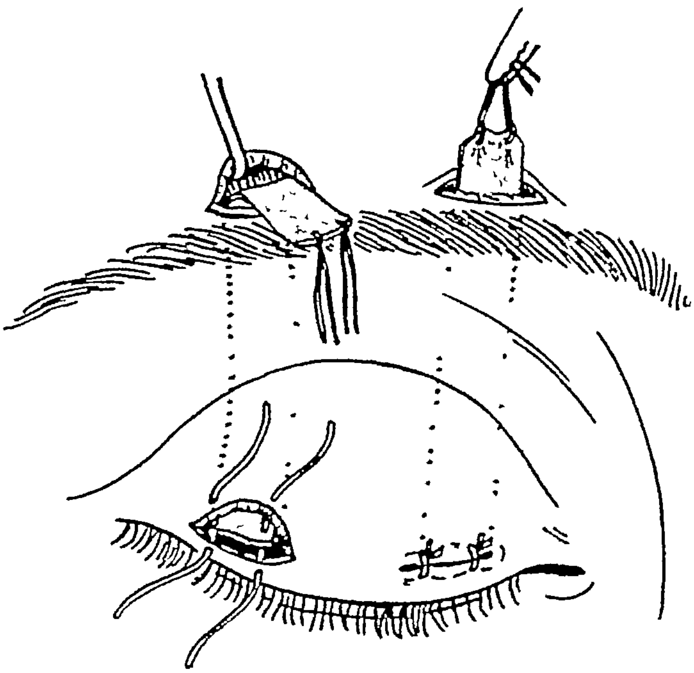


FIG 515 Elevation of lid by use of fascia lata strips Two incisions made above eyebrow, to expose epicranius, and 2 incisions made above lid margin, to expose tarsus Intervening skin undermined, to form tunnels Two strips of fascia drawn through Lower ends secured to tarsus by sutures so passed as to simultaneously close skin wounds Traction exerted on upper ends of fascia, to secure desired elevation of lid, and strips fixed to epicranius (Lexer)

of the middle and inner thirds and the other at the junction of the middle and outer thirds The upper margins of these incisions are undermined for a few millimeters to expose the epicranius muscle Two incisions of similar length are then made 3 mm above the lid margin just medial to those in the eyebrow. The skin between the upper and lower incisions is undermined in such a way that 2 tunnels are constructed

converging slightly downward toward the lid margin. A Reverdin needle is passed from above downward and is made to emerge through the incision at the eyelid margin. The needle is threaded with a suture passed through the end of a strip of fascia lata 1 cm wide and is withdrawn, leaving the fascia in the canal The same procedure is carried out on the other side of the lid The lower end of each fascia strip is secured to the tarsus by means of 2 or 3 sutures so passed that when tied the small skin wounds above the eyelid rims will be closed. Sufficient traction is exerted upon the upper ends of the strips to form a normal fold and bring the lid margin to within 3 mm of the upper margin of the cornea and on a level with the upper fifth of the pupil This degree of elevation allows for a further shortening of 1 mm when the strips contract. The upper ends of the strips are then sutured to the epicranius with silk, and the

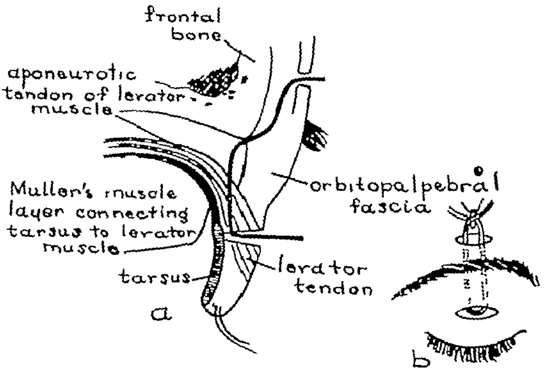


FIG 516 Elevation of lid by use of fascia strip tarso-orbital fascia being employed as pulley a sagittal section showing course of transplant. b fascia in place. For details, see text. (Hildreth)

skin wounds are closed The cicatrix above the eyebrow will subsequently be lost in the hair line, and the 2 small palpebral scars will become imperceptible (fig 515)

Hildreth's Operation Hildreth (41) employs the tarso-orbital fascia as a pulley to draw the lid against the eyeball, and chooses ox fascia rather than fascia lata to attach the lid to the epicranius. He claims that the implant will not cause a foreign body reaction, because the alcohol in which it is preserved destroys the antigen But with autogenous fascia so easily obtainable with the aid of a stripper (p 198), there would seem to be no advantage in the use of heterogenous material. Hildreth's technic is as follows A transverse incision 1 cm. long is made in the center of the upper lid at the level of the upper border of the tarsus. A similar incision of equal length is made above the first, at a point 1 to 2 cm above the eyebrow A Blair needle is introduced through the lower wound and passed upward and slightly backward behind the orbital fascia, until the point strikes against the roof of the orbit just inside the orbital rim. From

here it is pushed forward and upward to perforate the orbitopalpebral fascia, and is made to appear through the upper incision A strip of fascia 8 to 10 cm long and about 1 mm wide is threaded into the eye of the needle and drawn through the channel The empty needle is then inserted through the upper incision and carried out through the lower incision, threaded with the fascia and withdrawn Thus the lower end will be looped through the deep tissue at the level of the upper border of the tarsus and afford a firm attachment without the need of suturing at this point The balance of the operation is carried out as already described (fig 516)

Operations Designed to Transfer Function of Levator Palpebrae to Superior Rectus Muscle

Motais' Operation The first surgeons to restore mobility to the paralyzed lid by the use of the superior rectus muscle were Motais (65, 66) and Parinaud (69, 70) The former dissected out a flap from the center of the muscle, passed it through an incision in the tarso-orbital fascia, and drew it into a pocket between the orbicularis muscle and tarsal plate, where he anchored it in position The technic is as follows The upper lid is everted by means of a hook retractor, and the globe is pulled downward with a traction suture passed through the conjunctiva at a point just above the limbus. A horizontal incision 1 5 to 2 cm long is made in the conjunctiva over the point of insertion of the superior rectus From the center of this incision a second incision is carried vertically upward to the upper level of the tarsus The conjunctiva is dissected up to expose the tendon of the superior rectus, and a squint hook is passed underneath the bared tendon The middle fibers of the tendon are seized with a fine hook, and at a point 2 or 3 mm from its insertion a transverse incision 3 mm. long is made through the full thickness of the tendon From the extremities of the transverse incision 2 parallel vertical incisions 10 to 12 mm in length are carried backward toward the point of origin of the muscle The muscle flap thus outlined, with its pedicle lying posteriorly, is raised Just above the upper end of the vertical incision in the conjunctiva a transverse incision is made through the orbital fascia, and through this opening the tissue from the anterior surface of the tarsus is detached to form a pocket extending to the lower border of the lid Through the free end of the tendon flap previously raised a double-armed suture is passed, the loop being made to lie on its under surface With the 2 threads which project on the upper surface of the flap acting as guide sutures, the flap is drawn forward into the pocket between the anterior surface of the tarsus and the orbicularis The threads are brought out just above the free border of the lid and tied over a roll of gauze, tightly enough to overcorrect the ptosis Finally, the conjunctival wounds are closed (fig 517)

Wiener's Operation. Wiener (88) modifies Motais' operation by reversing the procedure Instead of mutilating the rectus muscle, he attaches to its intact tendon the paralyzed levator, claiming that the attachment is not so precarious, that the operation leaves no tenting effect in the middle of the upper lid, and is easier to perform He proceeds in the following manner (fig 518) "The tarsus is exposed by an incision across the center of the upper lid near the upper border of the tarsus, the main portion of the levator near the tarsus is exposed between two hooks, two sutures are placed close to its insertion in the tarsus, and the levator then is cut off about 6 mm from its tarsal attachment. A pocket is made, with a straight, blunt scissors, through the levator and fascia about 15 mm. above the upper border of the tarsus and through the conjunctiva into the upper culdesac The speculum is introduced, and the conjunctiva

is dissected down to expose the superior rectus tendon, which is freed of capsular attachment. The sutures are drawn into the upper culdesac and sewed, one to each side of the superior rectus tendon about 5 mm. back from its insertion. Fine silk sutures are used. No suture is required for closure of the conjunctival incision and only one skin suture is necessary in the lid. The eye is protected with a light dressing by pulling

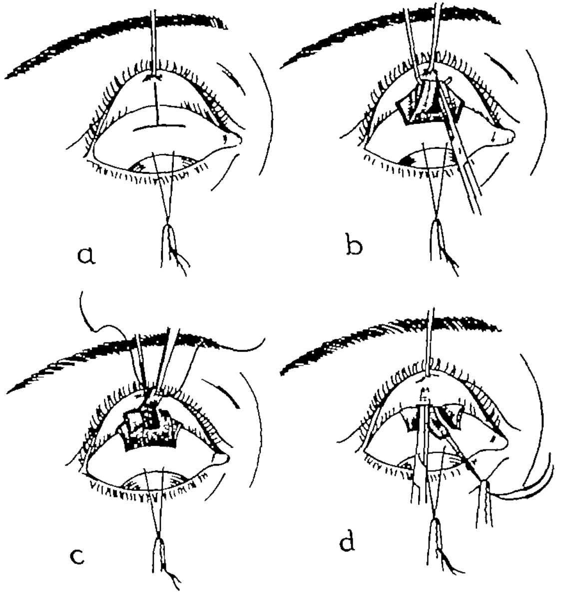


FIG 517 Correction of ptosis by transfer of function of levator palpebrae to superior rectus muscle. *a*, upper lid everted, and eyeball immobilized by suture. Horizontal incision made over insertion of superior rectus, from center of which vertical incision is carried to upper level of tarsus. *b* conjunctival flap turned back, to expose superior rectus which is elevated by squint hook. Full thickness muscle flap, pedicled posteriorly cut from its center *c*, muscle flap raised, and silk loop passed through it. *d* tissue on anterior surface of tarsus undermined, to form pocket. Muscle flap drawn through by suture and tied over gauze rolls under sufficient tension to correct ptosis. (Motais)

up the lower lid by means of a broad piece of adhesive stretched from the cheek to the forehead, which eliminates pull on the upper lid and effectively covers the globe. No dressing is needed after 48 hours The adhesive strip is applied at night until the lid closes of itself '

Wheeler's Operation. Another modification of Motais operation is the procedure

of Wheeler (82, 86) who attached the orbicularis oculi muscle to the superior rectus as follows (fig 519): Anesthesia is obtained with avertin and the local injection of procain hydrochlorid A skin incision 25 mm long is made across the lid a few millimeters above the upper border of the tarsus The skin below the incision is freed from the orbicularis to the margin of the lid, and that above the incision is separated for a distance of about 10 mm Through the orbicularis oculi muscle 4 or 5 mm above the tarsus, a horizontal incision is made and deepened through the tarso-orbital fascia and

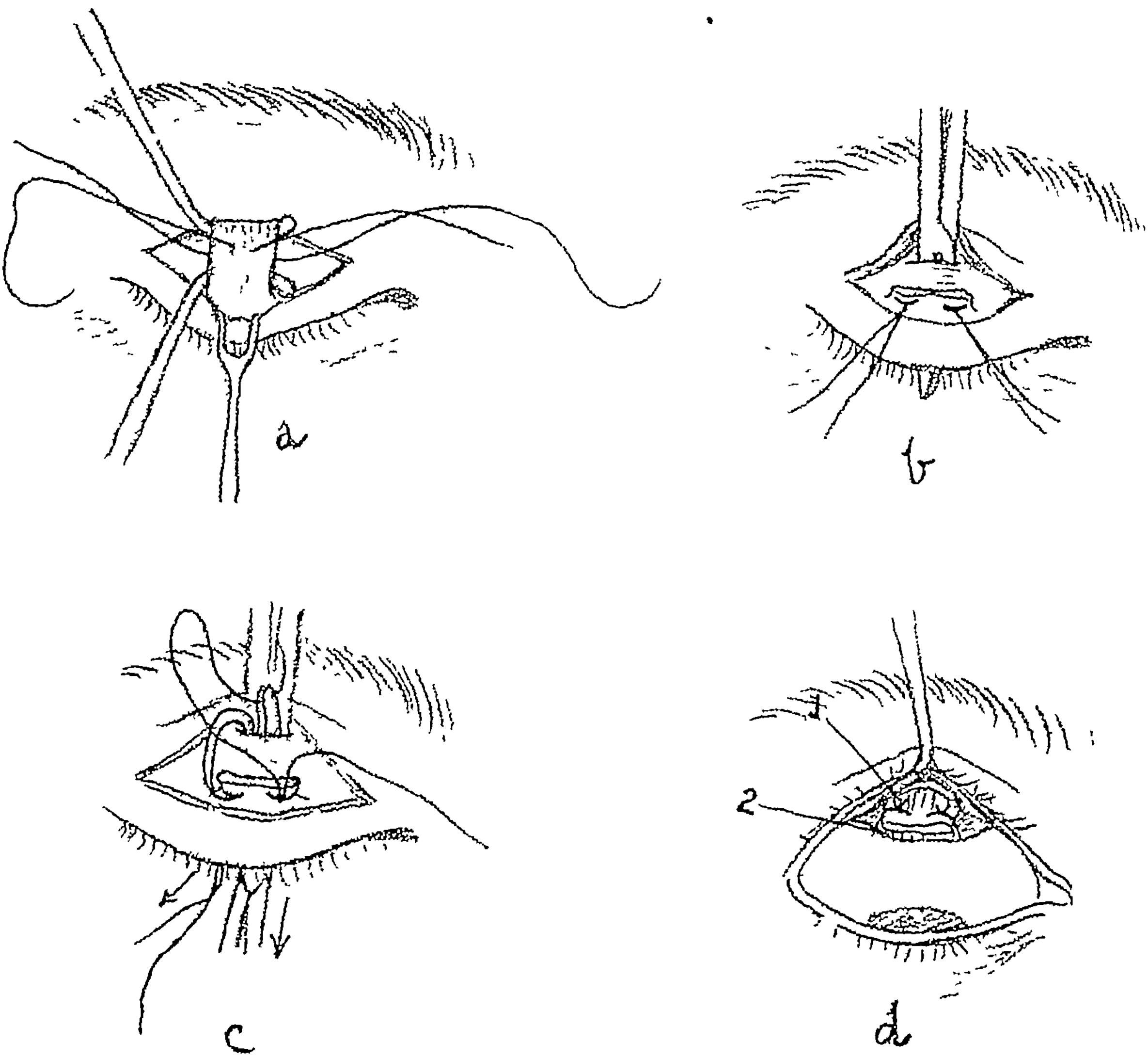


FIG 518 Correction of ptosis by attachment of paralyzed levator palpebrae to intact tendon of superior rectus *a*, levator exposed and held between 2 hooks while sutures are passed *b*, levator cut Opening made through fascia and conjunctiva into upper cul-de-sac *c–d*, levator sutured to superior rectus For details, see text (Wiener)

the levator tendon The dissection is then continued through Tenon's capsule to the sclera on each side of the superior rectus muscle The superior rectus is dissected up and a squint hook passed beneath it From the orbicularis two strips of muscle about 4 mm wide and 10 mm long are raised, a bridge of attached muscle about 8 mm long being left between them These muscle flaps are attached to the upper surface of the superior rectus by means of two sutures of fine #000 chromic catgut The skin wound is closed A thin layer of absorbent cotton dipped in warm water and pressed dry is

molded to form a cone, its base being large enough to cover the orbit. The cone is filled with sterile petrolatum and placed over the lids. Over this and extending somewhat beyond the cone is laid another layer of moist cotton. This in turn is covered with a third layer, and the whole is fixed in place with adhesive strips. The dressing is removed in a week.

Greeves' Operation. Greeves attaches the tarsal cartilage of the upper lid to the superior rectus in the following manner (fig 520) The eyeball is rotated downward by traction exerted on a suture passed through the conjunctiva just above the limbus.

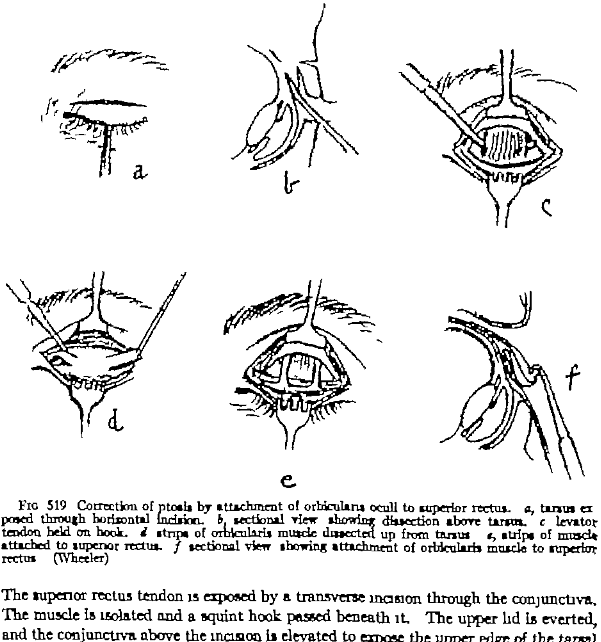


Fig 519 Correction of ptosis by attachment of orbicularis oculi to superior rectus. *a*, tarsus exposed through horizontal incision. *b*, sectional view showing dissection above tarsus. *c* levator tendon held on hook. *d* strips of orbicularis muscle dissected up from tarsus *e*, strips of muscle attached to superior rectus. *f* sectional view showing attachment of orbicularis muscle to superior rectus (Wheeler)

The superior rectus tendon is exposed by a transverse incision through the conjunctiva. The muscle is isolated and a squint hook passed beneath it. The upper lid is everted, and the conjunctiva above the incision is elevated to expose the upper edge of the tarsal cartilage. Two strips of cartilage are turned upward and sutured with fine silk to the sides of the superior rectus tendon. A bandage is applied. The sutures are removed on the tenth day

Jameson's Operation. Jameson (45) modifies Parinaud's (70) procedure by utilizing the entire strength of the unmutilated superior rectus muscle, as follows From the

outer and middle thirds and well down toward the lid margin This suture is then passed through the folded fascia-lata strip , is tied, and the suture cut Another double-armed white-silk mattress suture is placed in a similar position at the junction of the inner and middle thirds of the tarsus The lid clamp is removed and by traction on the fascia loop or sling the point is determined where the second suture should be placed through the fascia lata. One knot is tied, and if, after inspection, the position of the lid is satisfactory, the second knot is tied The position of the lid may be varied by lengthening or shortening the fascial sling The point chosen for the second mattress suture should be one that will lift the lid margin to a point about 3 mm below the limbus A second pair of mattress sutures is passed through the tarsus and fascia lata to insure a firm attachment The excess fascia lata then is cut off close to

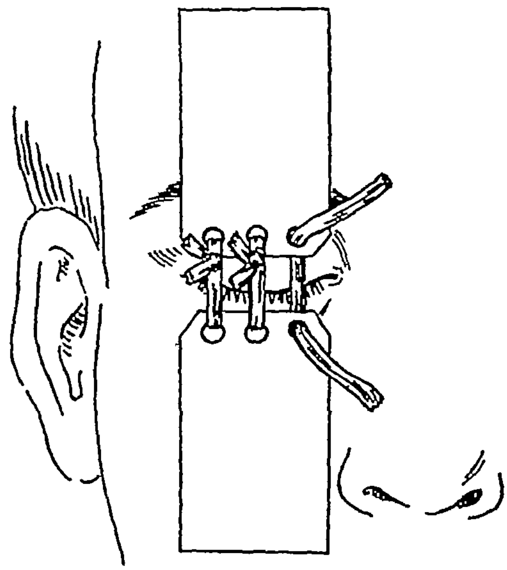


FIG 523 Temporary approximation of lids by use of laced adhesive strips

the second suture The skin incision is closed with a continuous subcuticular suture (fig 522-d, lid drawn down to show site of incision and subcuticular stitch)."

LAGOPHTHALMOS

Lagophthalmos is a condition characterized by inability to approximate the eyelids It may be paralytic, in which case it arises either from an isolated involvement of the nerve fibers that supply the orbicularis oculi muscle or, as is usually the case, as a part of a unilateral facial paralysis, it may be cicatricial, due to contraction of scars from burns, ulcers, and trauma which tends to narrow the lids in a vertical direction, or it may be consequent upon an exophthalmos Treatment is imperative, in order to prevent desiccation of the cornea from constant exposure, and if for some reason the proper measures have to be delayed, the eye must be protected in the interim. If the lids can be approximated, they are held together either by means of adhesive straps (fig 523) or by a temporary tarsorrhaphy (fig 464). If approximation is impossible, a watch crystal containing moist cotton is applied to the eye and fastened to the surrounding skin with adhesive straps

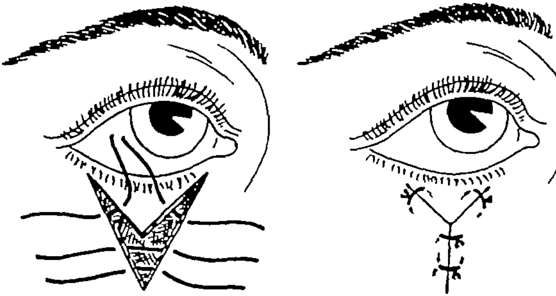
The operative management of lagophthalmos will naturally depend on the underlying cause If it is cicatricial, the scar tissue is excised and the loss replaced according

to one of the methods described in Chapter II. The treatment of the paralytic form of the condition is discussed in the section dealing with facial paralysis.

ECTROPION

Ectropion is the most common affection of the eyelid and demands prompt correction. If neglected, it predisposes to ulceration and nebulous changes in the cornea by reason of exposure, furthermore, the flow of tears over the cheek, caused by the eversion of the punctum, results in inflammation and excoriation, and the added weight of the lid consequent upon the inflammation further exaggerates the condition.

For surgical purposes, ectropion is classified etiologically as either cicatricial or non-cicatricial. In the former the contraction of scar tissue shortens the vertical length of the lid and causes the conjunctiva to be drawn forward and away from the lid margin.



a b

FIG. 524 Jones operation for relief of mild cicatricial ectropion *a*, V-shaped incision embracing scar made in lower lid. Skin undermined, and cicatricial bands removed until lid assumes normal position. *b* V-shaped incision sutured in form of Y increasing length at expense of breadth.

The non-cicatricial type may be (1) *Senile or paralytic*, caused either by a relaxation of the palpebral tissue or a paralysis of the orbicularis oculi muscle. In either case the skin becomes flabby the muscle loses its tone, and the lid is no longer kept pressed against the eyeball, but sinks by its own weight. In time the orbicularis muscle slips behind the inferior border of the tarsus, thus increasing and maintaining the eversion (2) *Spastic* due to a spasm of the orbicularis oculi muscle (3) *Mechanical*, the eyelid being forced away from the eyeball as a result of a thickening of the conjunctiva, of staphyloma, ectasia, tumors, etc.

Treatment of Cicatrical Ectropion

In the cicatricial type of ectropion the indication is to release the eyelid from its binding adhesions, so that the lid can resume its normal relation to the eyeball

In the case of slight eversion caused by a few cicatricial bands, correction can some

times be effected by subcutaneous division or excision of the bands, followed by re-adjustment of the overlying skin on a new base This principle is illustrated in the Jones (46) type of operation (fig 524), of which the details are as follows. A V-shaped incision embracing the scar is made in the lower lid The skin within the triangle is undermined, until the lid rises into its normal position The bands of subcutaneous scar tissue are excised The remaining wound is sutured from below upward, so that the V is changed to a Y. A similar procedure is illustrated in Figure 525 Another method sometimes resorted to for the correction of mild forms of ectropion is that based on the principle of the transposed flap, as shown in Figure 526 When the above methods are employed, the eyelids are kept immobilized by a tarsorrhaphy until all tendency to recurrence of the condition has disappeared

In more marked forms of cicatricial ectropion the scar tissue must be excised and replaced with some form of graft or flap, as described on page 842 The use of a skin graft for this purpose is demonstrated in Figure 527. Spaeth (75) offers an excellent

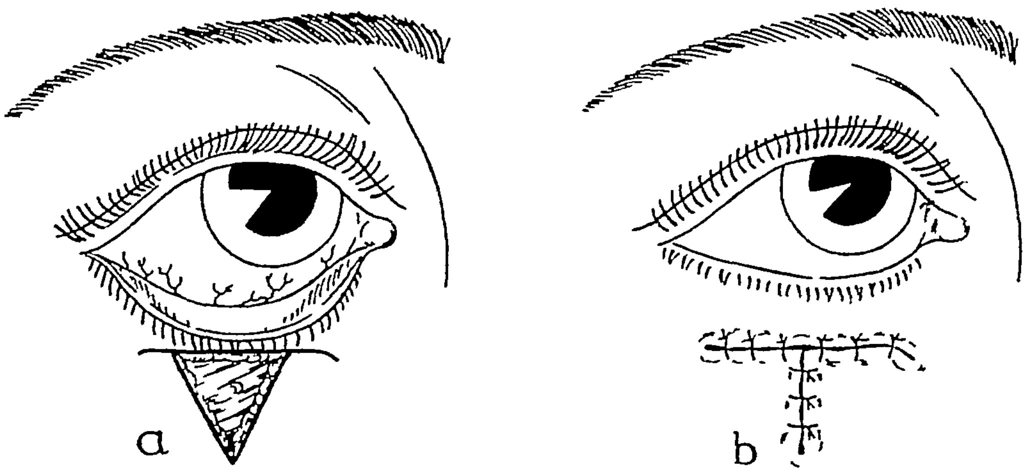


FIG 525 Dieffenbach operation for relief of mild cicatricial ectropion *a*, horizontal incision made below lid margin, and scar tissue removed in form of triangle Tissues undermined and readjusted Wound sutured in form of T

suggestion for the planning of this type of correction Cellophane is placed directly over the part and the defect traced on it with a red wax pencil From this pattern is calculated the necessary resection of the scar and the readjustment or replacement of tissue

Treatment of Non-Cicatrical Ectropion

For the non-cicatricial type of ectropion, where the eversion is due to an abnormal length of the lid margin, the correction, unlike that of the cicatricial form, does not contemplate the *addition*, but rather the *excision* of tissue, with a view to increasing tension from side to side and permitting the lid to reapply itself to the eyeball

For the correction of *mild forms* Snellen's (73) suture has been recommended (fig 528), in the hope that cicatricial bands will form to hold the lid in its corrected position; but the operation is for the most part impracticable With modern aseptic surgery the formation of these cicatricial bands is negligible, and those that do arise give way in time, and the deformity reappears The procedure finds application only to senile ectropion or to slight degrees of spastic ectropion. The technic is as follows: Two

heavy loops of # 3 twisted black silk, one at the junction of the outer and middle thirds, the other at the junction of the middle and inner thirds of the eyelid, are passed beneath the skin and tied thus One needle of a double-armed suture is entered through the summit of the ectropionized conjunctiva and the tarsal plate. From this point it is

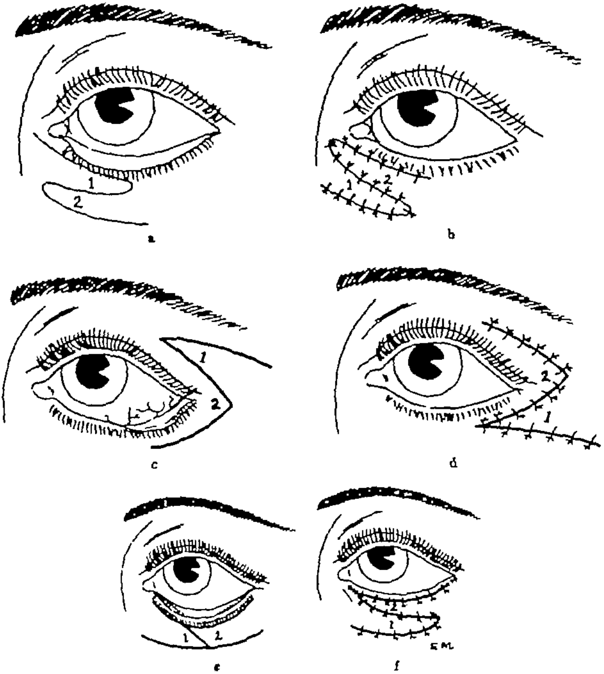


FIG. 526. Relief of mild forms of ectropion by use of transposed flaps. *a*, ectropion at inner canthus Flaps *1* and *2* outlined by Z-shaped incision. *b* flaps transposed. *c* ectropion at outer canthus Flaps *1* and *2* outlined. *d* flaps transposed. *e*, ectropion involving entire length of lid. Flaps *1* and *2* outlined. *f* flaps transposed.

made to pass beneath the skin of the lid and is brought out on the skin surface at a point opposite the lower margin of the orbit. The second needle is passed in a like manner at a distance of 8 mm. from the first and parallel to it. The ends of the 2 loops appearing on the cheek are tied over rolls of gauze, the inferior border of the tarsus being

thus pulled downward and forward, so that the margin of the lid comes to lie in contact with the eyeball The sutures are allowed to remain for 2 or 3 weeks

For permanent results the lid must be shortened from side to side With this purpose in mind, Adams (2) excised a triangular section of full thickness tissue from the central portion of the lid, the base of the triangle lying at the lid margin, and closed the defect by direct approximation—the conjunctiva, tarsus, and skin being sutured separately and on different planes This procedure did not prove successful, because the septic nature of the conjunctival sac interfered with primary healing. Von Ammon (4), in an effort to overcome this difficulty, excised the wedge near the outer canthus instead of from the center of the lid, but this procedure led to the same undesirable results

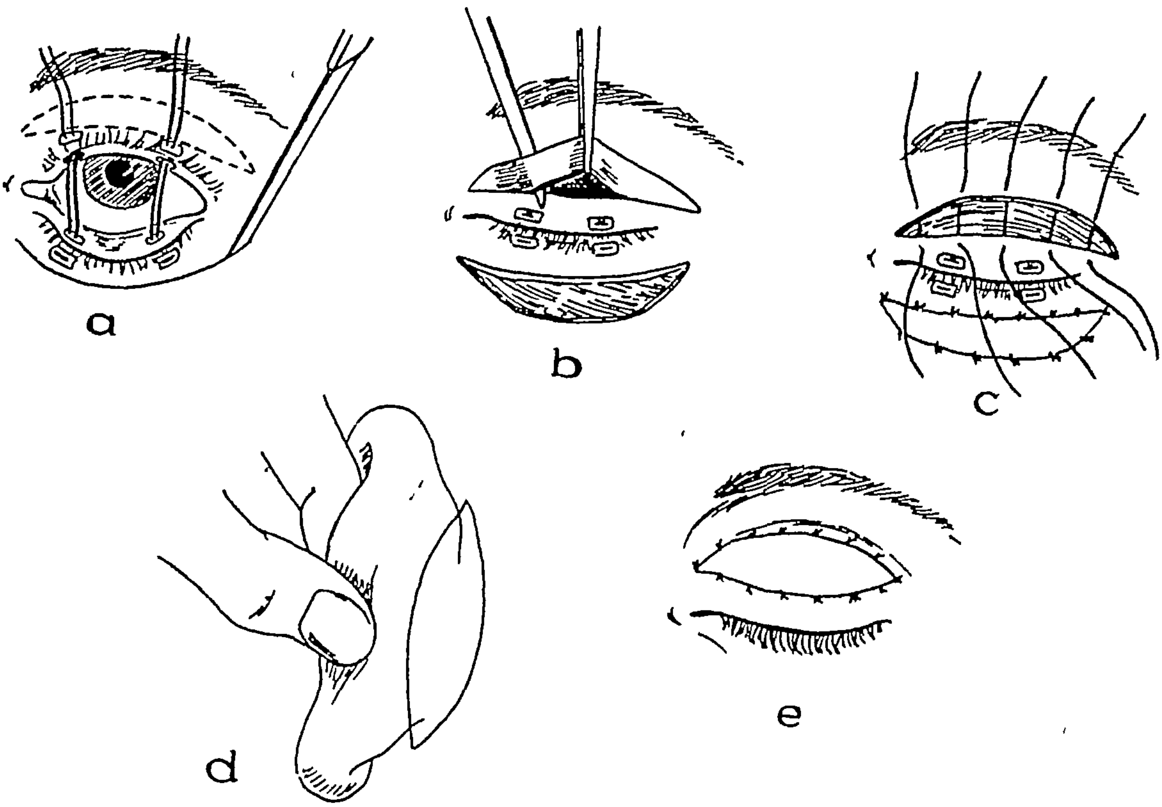


FIG 527 Relief of cicatricial ectropion by use of skin graft. *a*, incision made below lid, and cicatricial tissue removed until lid can be made to assume its normal position Sutures for immobilization of eyelids passed Dotted line indicates graft to be removed from upper lid *b*, lids immobilized Skin graft cut from upper lid *c*, graft fixed in place Sutures passed for approximation of secondary defect *d*, graft cut from cephalo-auricular angle, to cover raw area following excision of scar tissue from upper lid *e*, graft sutured in place (Wheeler)

Kuhnt (53) later modified the above methods by excising a triangle of conjunctiva and tarsal cartilage only, leaving the skin intact. In order to overcome the redundancy of skin, the excess was excised at the outer canthus after free mobilization had been secured (77, 20) *Technic* (fig 529): An intermarginal incision is made in the lid, beginning at a point just medial to the ectropion and extending to the outer canthus The inner lamina, consisting of conjunctiva and tarsal plate, is picked up with a forceps to estimate the amount of shortening required The triangle of conjunctiva and tarsus thus delineated, with its base at the margin of the lid and its apex below the lower border of the tarsus, is excised with a pair of straight scissors, the skin being left intact Ordinarily the base of the triangle ranges in length from 0 5 to 1 cm (53). A triangular

section of skin is then excised at the outer canthus in the following manner An incision directed outward and slightly upward is made at the outer canthus equal in length to the base of the triangular piece of tarsus already removed. From the end of this incision an oblique incision about twice the length of the horizontal one is carried down to a point below the outer commissure. The skin of the lid is then mobilized and

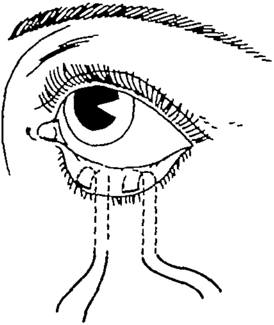


Fig 528. Snellen suture for relief of spastic or senile ectropion. Two loops passed through summit of ectropionized conjunctiva and tarsal plate, and carried beneath skin, to emerge below margin of orbit. Ends tied over gauze rolls under sufficient tension to turn lid margin inward.

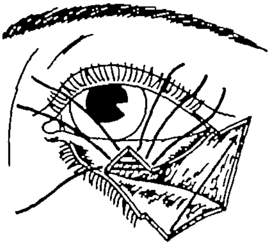


Fig. 529 Relief of non-cicatricial ectropion by shortening of lid margin. Lid split into 2 laminae by intermarginal incision. Triangle of conjunctiva and tarsus excised. Triangle of skin removed at outer canthus. Lid skin mobilized and drawn outward, to bring margins of tarsal wound together and cover triangular skin excision. Tarsal wound sutured. For details, see text. (Kuhnt Szymanowski)

drawn toward the outer canthus, so that the margins of the tarsal wound come into approximation and the external triangle is covered. That part of the overlapping free border containing the eyelashes is excised. With the lid everted, the tarsal wound is united from below upward by means of 3 silk sutures, the topmost catching the tarsal edge near its upper margin. These stitches are passed from without inward,

so that the knots will lie on the outside Suturing of the skin is begun by fitting the outer angle of the lid flap to the outer angle of the wound bed

ENTROPION

Entropion is a condition characterized by inversion of the eyelids For surgical purposes it may be classified as either (1) *spastic* or (2) *cicatricial*. The former type is due to spasm of the orbicularis oculi muscle, especially in the absence of the proper support, and is prone to occur in the aged in whom the eyeballs are sunken and the lid skin is loose and flabby Normally, the orbicularis oculi muscle forms a curve with its concavity toward the lid margin, and contraction serves to press the lid against the eyeball In the absence of normal support the contraction produces a rolling in of the lid The irritation produced by the inverted lid increases the blepharospasm, and this in turn exaggerates and maintains the entropion The condition is usually limited to the lower lid, as in the upper lid the tarsal cartilage is too strong to be distorted by the muscle

FIG 530 Relief of spastic entropion by use of subcutaneous sutures Sectional view, showing effect of suture when tied For details, see text. (Gaillard-Arlt)

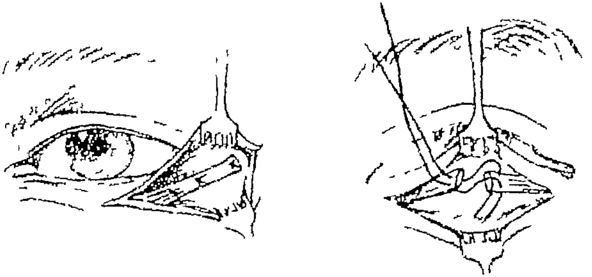
The cicatricial form is due to scars, usually following burns, and may affect either lid The contraction of the scar tissue may involve the lid margin alone, resulting in its distortion, as well as a maldirection of its eyelashes (trichiasis), or it may affect the tarsal plate and cause it to become curved in a short radius, thus forcing the eyelid inward

TREATMENT OF SPASTIC ENTROPION

Many methods have been suggested for the correction of this condition Some of these procedures are based on the anticipated formation of cicatricial bands in the lid tissue, but except in the mildest forms of entropion they fail to produce a permanently satisfactory result As has been said before, these bands usually fail to appear, and when they do form, they have a tendency to stretch and lead to a recurrence of the deformity An example of this type of operation is that of Gaillard-Arlt (5, 30), of which the details are as follows.

One needle of a double-armed silk suture is passed through the skin at the junction of the middle and inner thirds of the lower lid about 3 mm. below the lid margin and made to emerge on the cheek 2 cm. below The second needle is passed beneath the skin parallel to the first at a distance of about 2 mm. from it. The point of entry and emergence of both needles should be on the same level, so that the loop will lie on the skin near the border of the lid. A similar loop is passed at the junction of the middle and outer thirds of the lid. The 2 ends of each suture are drawn taut over small rolls of gauze and tied the horizontal fold of skin thus pinched up serving to relieve the entropion (fig 530) The sutures are removed in from 2 to 3 weeks, and if in the interim there is any slackening they may be tightened.

A more satisfactory operation contemplates the removal of redundant skin and underlying orbicularis muscle, as follows An incision is made about 3 mm from the eyelashes along the whole length of the lid. A second crescentic incision is made below,



a b

Fig. 531 Relief of spastic entropion by strips of orbicularis oculi muscle. *a*, strip of orbicularis oculi attached to zygoma. *b*, strips of orbicularis muscle overlapped and attached to tarso-orbital fascia For details, see text. (Wheeler)

joining the first incision at each extremity The included skin and underlying muscle are removed, and the margins of the wound are approximated by means of an intradermal suture. The resultant scar will be scarcely perceptible.

Wheeler (86) corrected the condition by the use of strips of orbicularis oculi muscle as follows A skin incision is made along the outer $\frac{1}{3}$ of the eyelid 5 mm below the lid margin (fig 531-a) A strip of orbicularis muscle about 4 mm. wide is dissected from the outer $\frac{1}{3}$ of the eyelid a little below the tarsus. This strip is drawn up and attached to the periosteum of the zygoma. The tautness of the strip will hold the lower border of the tarsus against the eyelid and tend to evert its upper border In some cases Wheeler found it of advantage to shorten the orbicularis muscle, thus (fig 531 b) An incision 5 mm from the lid margin is made along its entire length, and through this a strip of orbicularis muscle 4 mm. wide is dissected from the lower part of the tarsus and divided in the middle A fine double-armed suture is carried through the tarso-orbital fascia below the tarsal plate. Then both needles are carried through the strips of the orbic

ularis 4 to 5 mm from their ends. When the sutures are tied, an overlapping of 4 or 5 mm. results, and the orbicularis muscle is thrown in contact with the tarso-orbital fascia just below the tarsus Pressure of the shortened strips at the lower tarsal border prevents a recurrence of the entropion The skin is then closed in the usual manner

Treatment of Cicatrical Entropion

The treatment of cicatricial entropion will depend upon the part of the lid affected. When the deformity is confined to the lid margin, correction is accomplished without an attack upon the remainder of the lid.

If there is merely a maldirection of a few eyelashes, they may be removed by repeated epilation or by recourse to electrolysis For electrolytic epilation the necessary instruments include a platinum needle fitted into a handle, and a galvanic battery equipped with a rheostat and galvanometer. The patient is placed in a position of good oblique illumination The lid is supported on a plate spatula, and the ciliary margin is anesthetized The surgeon, with the aid of a binocular loupe, passes the platinum needle

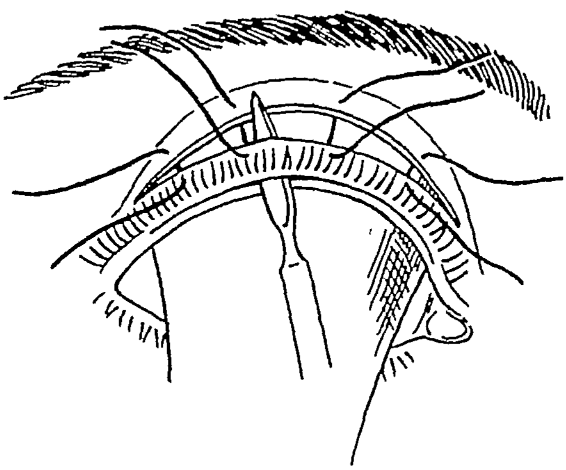


Fig 532 Relief of cicatricial entropion limited to lid margin Incision made along gray line Semilunar section of skin excised Bridge flap containing eyelashes sutured to upper border of wound Raw surface below covered with skin previously excised, or by a mucous membrane graft For details, see text (Jaesche-Arlt-Truc)

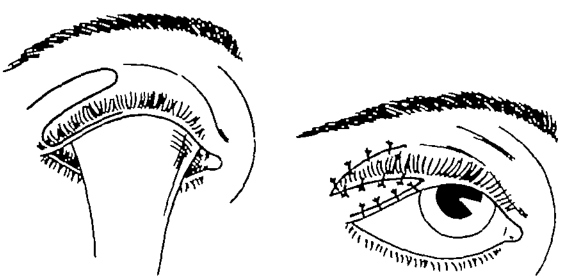
connected with the negative pole along the shaft of the eyelash down into the follicle for a distance of 2 to 3 mm The current is then turned on, and 0 5 to 1 milliampere is introduced for 20 to 30 seconds, after which the current is gradually shut off. The needle is withdrawn, and the hair is removed Electrolytic action is manifested by bubbles of gas appearing around the needle

When more than a few hair follicles are involved, the above procedures are inapplicable, and many operations have been devised with the aim of removing the eyelashes from the danger zone One type of operation contemplates raising the line of eyelashes in the form of a bridge flap and implanting it at a higher level, as follows: An incision about 5 mm in depth is made in the gray line of the lid throughout its entire extent (fig 532) A second incision of the same length is made in the skin of the lid 5 mm above the eyelashes A bridge of tissue is thus formed, containing the lashes and their follicles A third curved incision is now made above the second, lying 4 to 5 mm above its central point and converging with it at both extremities The semilunar area of skin thus outlined is excised and placed in warm normal salt solution for later use

The bridge flap containing the eyelashes is raised and stitched to the upper border of the semilunar area with interrupted silk sutures. The crescentic piece of skin previously excised is placed over the raw area between *the lid border and the eyelashes* as a full thickness skin graft, secured in place by means of sutures, and covered with a pressure dressing. After 8 days the dressing is discarded, and the sutures are removed.

Van Millingen (62) operates in much the same manner, but in order to eliminate the possible irritation of the cornea by the downy hairs on the skin graft, he uses mucous membrane in place of skin to fill the space between the lid margin and the elevated ciliary line.

While the foregoing operations relieve the trichiasis, the uncertainty as to whether the graft will "take" and the subsequent disfigurement occasioned by the procedures have *led many surgeons to discard grafts and resort to the use of narrow flaps taken* from the lid. The technic is briefly as follows (31, 59, 11). An intermarginal incision is made in the lid throughout its entire extent. A second incision is then made parallel



a b

Fig. 533 Relief of unilateral cicatricial entropion by use of transposed flaps. *a*, two flaps outlined above lid margin. *b*, flaps elevated and transposed, so that eyelashes come to lie at higher level. For details, see text. (Watson)

to the lid margin and 3 or 4 mm. above it, this incision extending 1 to 2 mm. beyond each end of the intermarginal one. A third incision is now made 1 mm above the second, of exactly the same length as the intermarginal, its extremities being curved downward to join the second incision. The intermarginal incision is next deepened to the second incision and beneath the bridge of skin thus formed the narrow flap of skin and muscle, still attached to the tarsus at both ends, is shifted downward to lie along the lid margin. It is secured to the tarsal cartilage by means of 2 *mattress-sutures, the* loops being buried in the tarsus and the ends carried through the skin about 2 mm. above the eyelashes, and the flap sutured. The raw surface lying above the flaps is obliterated by approximation of its margins with an intradermal suture of silk, and a bandage is applied. The stitches are removed in 4 or 5 days.

If the entropion affects only one side of the lid margin, transposed flaps may be used. An example of this type of operation *is that of Watson (79). The technic is as follows* (fig. 533). With the lid supported on a horn plate, an incision is made in the gray

line to a depth of about 6 mm , beginning at the commissure and extending to the limit of the entropion, the lid being thus divided into 2 laminae Another incision is carried through the anterior lamina above the rim margin in a slightly divergent direction, to a point 2 mm beyond the medial limit of the intermarginal incision Here the knife is turned, and a third incision is carried back toward the commissure Thus 2 small tongue-shaped flaps are outlined, the upper about 3 mm wide, with its pedicle at the outer canthus, and the lower, about 5 mm. wide, with its pedicle directed medially, and containing the affected eyelashes These flaps are dissected up and transposed, the upper flap being shifted beneath the lower, so that the eyelashes will come to lie at a higher level The flaps are secured in place with a few fine silk sutures

When the entropion is due to a faulty curvature of the tarsus, satisfactory results can be obtained only by a correction of the faulty angle Panas (68) suggested that

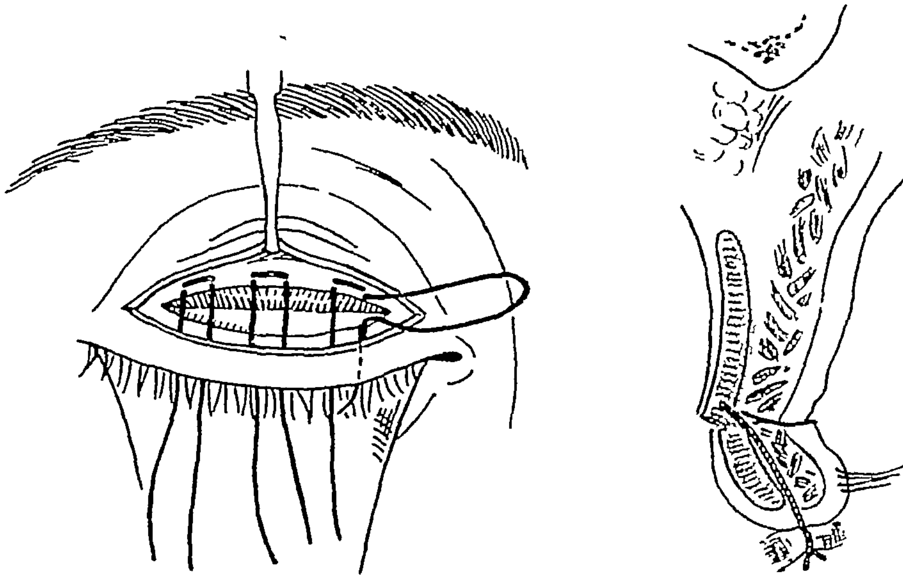


FIG 534 Relief of entropion by division of tarsal plate and tilting outward of part containing eyelashes *a*, tarsus exposed through horizontal incision Wound margins undermined Tarsus and conjunctiva cut through horizontally Lower margin of tarsus and free border of lid rotated outward and upward by sutures *b*, sectional view, showing effect when sutures are tied (Panas)

the tarsal plate be divided into 2 sections, and that the part containing the eyelashes be tilted outward, thus (fig 534). A horn plate is inserted beneath the affected lid, and an incision is made through the skin and muscle 6 to 7 mm. above and parallel to the entire lid margin The wound edges are undermined below as far as the free border of the lid and above to the upper border of the tarsus The tarsus and conjunctiva are then cut through their entire thickness, the incision being made to take the same course as the skin incision Thus the lower margin of the tarsus, together with the free border of the lid, is made movable, and by means of sutures it can be rotated outward and upward The sutures are passed above through the edge of the tarsus and the tarso-orbital fascia, brought out behind the skin of the lid along the intermarginal line, and tied over rolls of gauze or rubber plates

To avoid opening the septic conjunctival cavity, Snellen (73) advocated correction of the condition by bending the lid margin with its line of cilia outward, as follows·

The tarsal plate is exposed as in Panas operation. Along the site of the most marked bending a strip of muscle 1 to 2 mm. wide is excised. Throughout the entire length of the tarsal plate thus bared 2 incisions are then made, lying 2 mm. apart on the surface but converging in the substance of the cartilage to meet just above the conjunctiva. The wedge shaped section of cartilage, with its apex at the conjunctiva, is then removed, great care being taken to avoid perforation of the conjunctiva. The sutures are passed in the following manner A curved needle is introduced above the wound through the skin and the upper segment of the tarsus. It is then carried downward and backward through the lower segment of the cartilage and made to emerge just behind the lid margin. Three such sutures are passed. When they are tied, the lower segment bearing the eyelashes is rotated through an angle equal to the segment of cartilage removed. After the last suture has been knotted, the ends are gathered together and fastened to the skin above the eyebrow

MINOR DEFECTS OF EYELIDS

Epicanthus

Epicanthus is a deformity characterized by a crescentic fold of skin passing vertically downward from the root of the nose to the lower lid partially or totally covering

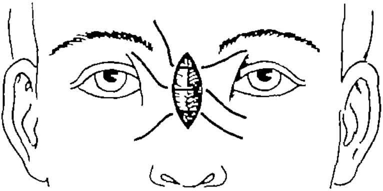


Fig. 535 Von Ammon operation for relief of epicanthus Elliptic section of skin removed from nasal dorsum. Wound margins undermined and approximated. (The resultant scar is conspicuous, with a tendency to become keloidal.)

the inner canthus and causing the root of the nose to appear broad and the eyes abnormally far apart. The condition may be congenital or it may be acquired from a loss of nasal support or cicatricial contraction. In children it is frequently encountered in moderate degrees, but as the dorsum of the nose becomes more prominent, it usually disappears spontaneously Therefore, correction should not be undertaken until the nose is fully developed, otherwise, the operative scar is apt to stretch with the growth of the bone and leave a deformity possibly more conspicuous than the original one In adults it may exist as an isolated defect, or it may be associated with other abnormalities. In the case of a coexistent saddle-nose it is well not to attempt to relieve the epicanthus until the bridge of the nose has been raised to the proper level, as it frequently happens that the epicanthus will disappear of its own accord as a result of the correction. Furthermore, should the order of the operations be reversed, the parts may be left in such a condition that correction of the saddle nose would be difficult due to loss or displacement of the tissues.

Treatment The first surgeon to attempt correction of epicanthus was von Ammon

(4) who excised an elliptic piece of skin from the dorsum of the nose, undercut the skin margins, and united the edges of the remaining wound directly (fig. 535) The

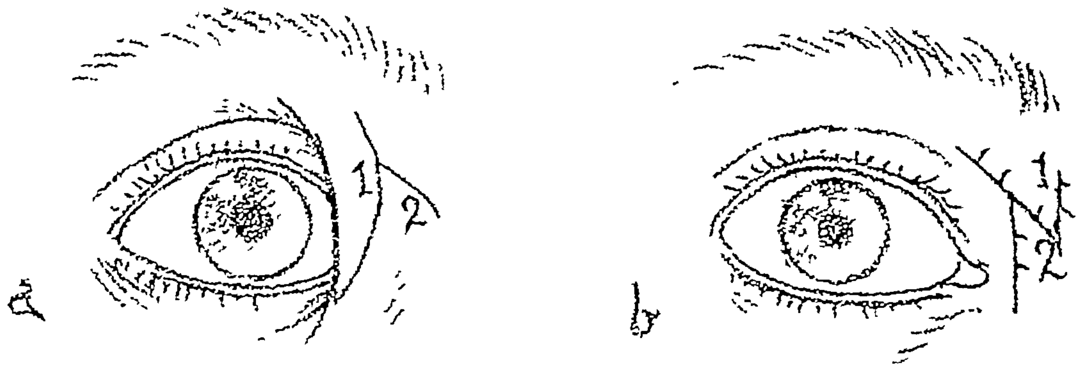


FIG 536 Relief of epicanthus by use of transposed flaps *a*, flaps outlined *b*, flaps transposed, diminishing transverse fulness and increasing vertical length (Blair)

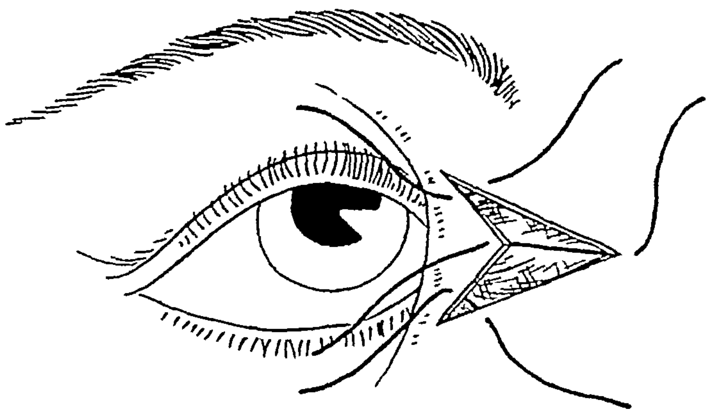


FIG 537 Wicherkiewicz operation for relief of epicanthus V-shaped incision with angle of 60 degrees made contiguous to inner canthus Section of skin removed, and wound margins approximated For details, see text

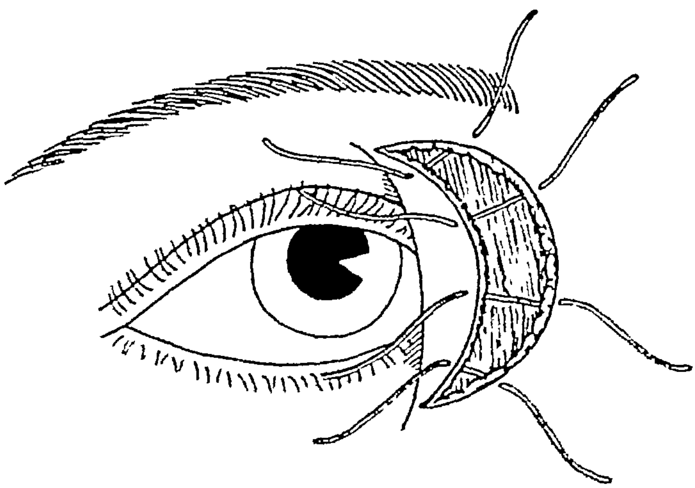


FIG 538 Blaskovics-Doyen operation for relief of epicanthus Crescentic section of skin removed Inner flap undermined Epicanthus relieved by suturing wound margins together

results of this operation are uncertain, and the subsequent scar has a tendency to become kelodial.

Blair (10), who believes the condition to be due to a vertical shortening of the tissues

medial to the inner canthus with an apparent redundancy in the transorbital direction, transposes flaps taken from the transverse fulness of the fold to replenish the vertical shortening (fig 536)

Wicherkiewicz (87) corrects the deformity in the following manner (fig 537) A V-shaped incision is made contiguous to the inner canthus, enclosing an angle of about 60°, the apex of the V lying medially, and the limbs extending to points 1 cm medial to the canthus. From the extremities of these 2 incisions another V-shaped incision is made, the limbs converging at a point 4 to 5 mm nearer the canthus. The

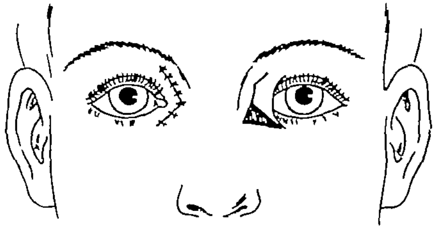


FIG 539 Relief of epicanthus by triangular excision of epicanthal fold and readjustment of tissues.

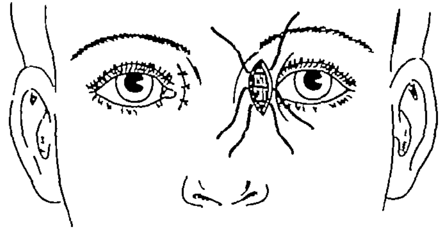


FIG. 540 Relief of epicanthus by oval excision of epicanthal fold and approximation of wound margins.

section of skin between the two V-shaped incisions is removed, and the margins of the wound are carefully drawn together the fold being thus obliterated.

A satisfactory procedure is that of Blascovics-Doyen. The technic is as follows A crescentic section of skin is excised, its concavity being directed toward the eye and its convexity toward the nose The inner flap is undermined, and the edges of the wound are approximated (fig 538)

Other operations designed for the correction of epicanthus are depicted in Figures 539-540

Outer Canthal Deformities

Occasionally a deformity resembling epicanthus is found in the vicinity of the outer commissure, due to rupture or absence of the lateral canthal ligament In the former case correction is accomplished by repair of the ligament But when the ligament is absent, its replacement by the use of strips of the orbicularis oculi muscle according to the method of Wheeler (86) is most satisfactory (fig 541)· An incision is made in the outer part of the upper lid about 3 mm from its margin A similar incision is made in the lower lid Through these incisions strips of orbicularis oculi are dissected up but left attached at the outer ends of the tarsal plates Through a small

Fig 541 Wheeler operation for correction of outer canthal defect *a*, defect *b*, horizontal incision made at outer canthus Additional incisions made in upper and lower lids, through which strips of orbicularis oculi muscle are dissected free, but left attached to outer ends of tarsal plates *c*, free ends of strip drawn beneath skin, crossed, and attached to periosteum of zygomatic bone

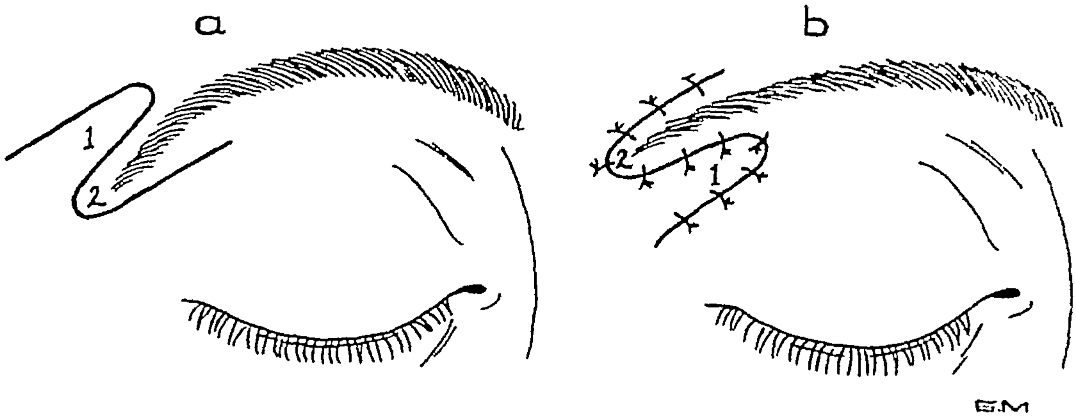


Fig 542 Correction of distortion of eyebrow by Z-plastic *a*, flaps outlined *b*, flaps transposed, to raise eyebrow to desired level

incision at the commissure the skin is undermined and the periosteum of the outer orbital region exposed The flaps of the orbicularis are crossed and attached to the periosteum of the zygomatic bone A suture is passed through the tissues at the outer end of each tarsal plate and tied Thus a new canthus is created The external wound is then closed in the usual manner

Distortion and Asymmetry of Eyebrows

Distortion of the eyebrows may be congenital, or it may be acquired from cicatricial contraction following burns and other injuries Correction is usually possible by readjustment of the tissues by means of various forms of advancement flaps, or with transposed flaps after the plan of the Z-plastic, as illustrated in Figure 542

Coloboma

Coloboma is a rare congenital deformity characterized by a more or less deep notch in the upper or lower lid. According to Fuchs (29), it is due to an imperfect union of the embryonic processes, but on the basis of this assumption it is hard to explain the position of the defects by the known embryonic relationship The condition is observed more often in the upper than in the lower lid, and frequently occurs in combination with other facial anomalies. If the notch is so large as to expose the cornea, it should be closed by one of the methods already described in the section devoted to loss of eyelid tissue. Wheeler's (81) halving operation finds special application in the correction of these defects (fig 462)

Corneal Opacities

In the case of a circumscribed semiopaque corneal opacity situated in the pupillary area, with clear corneal tissue in the vicinity, the dispersion of light caused by the semiopaque tissue leads to a blurring of the image formed by the normal cornea. Such blurring can often be relieved by tattooing the opacity This procedure will result in a blocking out of the light passing through it. Tattooing may also be resorted to for cosmetic purposes, to imitate a pupil in a blind eye which is otherwise normal in size and curvature. Various pigments have been utilized to this end The first pigment to meet with success was India ink, introduced in 1859 by de Wecker (80), who infiltrated a thick paste of the ink into the corneal parenchyma with the aid of needles. Other coloring matter has since been used, such as choroidal pigment obtained from animals, potassium ferrocyanid, iron sesquichlorid, gold chlorid, and platinum chlorid, the two latter giving the best results Knapp (50) employed a 1 to 5 per cent neutral solution of gold chlorid. This he applied to a previously denuded area for 2 or 3 minutes, after which he instilled adrenalin chlorid. Duggan and Nanavati (22) prefer gold chlorid and their technic is as follows The instruments required are 'Speculum, Graefe cataract knife, fixation forceps, cotton applicator, small glass containing a small quantity of gold chloride solution, small pieces of sterile blotting paper, small glass measure containing 1 per cent tannin solution, if a brown staining be desired or 2 per cent hydrazin hydrate, if a black color be required, medicine dropper and normal saline in an undine for washing the eye after using tannin or sterile tap water in case hydrazin hydrate is used.

"After anesthetizing the eye with 4 per cent cocaine solution, the speculum is inserted, the eyeball is fixed with fixation forceps at a convenient spot at the limbus and the surface epithelium covering the leucoma and a little beyond it, is scraped off with the knife. The fixation of the eye is given up, the cotton applicator is dipped into the 5 per cent gold chloride solution and the excess of the fluid is removed by pressing the applicator against the wall of the glass. The eye is fixed again and the applicator is firmly pressed upon the denuded surface for one minute. With a steady patient the fixation of the eyeball can be done away with, three or four such applications each lasting one minute are made. The surface of the eye is continuously kept dry by an assistant with the sterile pieces of blotting paper to prevent irritation of the eye The tannin or hydrazin solution is dropped on the denuded surface drop by drop for about twenty or thirty seconds until the denuded area becomes stained. Now the eye is washed either with saline or tap water according as the tannin or

hydrazin solution has been used After instilling atropine, vaseline is applied to the eye Both eyes are bandaged

"Atropine is instilled daily for a week and the dressings changed daily. The unoperated eye is left open on the third day and the operated eye on the ninth day"

With platinum chlorid Duggan and Nanavati use the following instruments and technic. "Speculum, fixation forceps, Graefe cataract knife, cotton applicator, sterile pieces of blotting paper, a small glass vessel to hold a small quantity of 2 per cent platinum chloride solution, a small measure glass containing 2 per cent solution of hydrazin hydrate, medicine dropper, and sterile tap water in an undine Both the solutions are freshly prepared before use.

"The eye is cocainized with 4 per cent solution of cocaine and the speculum applied. The eyeball is fixed with the fixation forceps at a convenient spot near the limbus whenever required during the operation The leucoma is scraped with the knife. The solution of platinum chloride is applied with the applicator by firmly pressing it against the denuded surface for one minute. A second similar application is done for another minute Two per cent hydrazin hydrate solution is dropped on the surface of the leucoma for about 25 seconds, during which period the leucoma is seen to turn black Throughout the operation the excess of solution is removed by an assistant with the sterile pieces of blotting paper. Finally the eye is washed with sterile tap water, atropine is instilled and vaseline applied before bandaging both eyes"

Contracted Socket

After enucleation of the eyeball it sometimes happens that the eye socket becomes partially obliterated by an adherence of the eyelids to the underlying structures, so that the retention of an artificial eye is impossible. In such cases the socket may be reconstructed by liberating the lids, excising the scar tissue, and lining the cavity with a skin graft (fig. 543).

Prior to operation all sources of infection must be eliminated and all deformities about the orbital margin and eyelids corrected (p. 838) Local infiltration anesthesia is resorted to, a 1 per cent solution of procain and adrenalin being employed.

In order that the dissection may be facilitated and the mold be easily introduced, the palpebral fissure is first widened by the performance of a canthotomy (p 840). Then with the lid margins held apart by means of hooks or traction sutures, an incision is made between them, and they are dissected from the underlying tissues in the conjunctival plane. Should a portion of the conjunctiva still be intact at the lid margin, the dissection is begun just above it Superiorly, the tissues are separated to the rim of the orbit, care being taken to preserve the levator muscle, if present Should the tarsus be thickened, it is resected, enough of its margin being preserved, however, to maintain the stability of the lid. Laterally, the separation is extended beyond the outer canthus, and medially, behind the canthal angle for a distance of 2 or 3 mm. If the caruncle is normal, the incision is carried posterior to it and to the junction of the maxillary and lacrimal bones Inferiorly, the tissues are separated as far as the level of the bony orbit All dissections are carried down to the periosteum, so that the graft may become attached to it and form a solid foundation for the prosthesis. At the upper bony rim, however, it is directed well away from the bone, with a view to preserving the orbicularis oculi and levator palpebrae superioris muscles After

the parts have been separated, all scar and granulation tissue is removed from the cavity, which is thus left smooth and free of projections. Hemorrhage is controlled by pressure when possible, but if ligation is unavoidable, the finest suture material should be used. The bed is sponged dry, and a *mold of the socket* is prepared.

A piece of softened stent is introduced into the prepared cavity, and the eyelids are drawn gently over it. The mold, which, as a rule, is about 35 mm. in diameter, 4 to 5 mm. thick, and 20 to 25 mm wide, is left in place until it hardens. This process can be hastened by the application of cold compresses over the part. Upon removal of the mold, cardinal points are scratched on its surface for purposes of future orientation. A razor graft of even thickness, preferably in one piece, is then cut from the inside of the arm (p 133) and smoothly wrapped around the mold, raw surface outward. The graft-covered mold is then introduced into the pocket in such a way

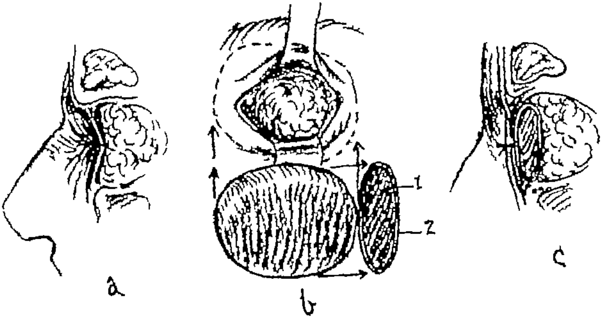


FIG. 543 Wheeler operation for restoration of contracted socket. *a*, sectional view of deformity. *b* eyelids held apart, to show bed for reception of graft. Dotted line indicates orbital margin. Below front and side views of graft-covered mold. *1* mold. *2* graft. *c*, graft in place. For details see text

that the overlap of the graft lies at the palpebral fissure. In order that there may be an even distribution of pressure throughout the transplant and no danger of the formation of hematomata, the lids are sutured together over the mold, the needle in its passage being made to take a bite of the graft. One or 2 layers of xeroform gauze are then laid over the lids, a slit being left over the palpebral fissure to permit of drainage. After this a pressure bandage is applied in the usual manner (p 124)

At the end of 10 days the pressure bandage is removed, the palpebral fissure is gently swabbed with moist cotton applicators, and a fresh dressing applied. A week later the dressing is permanently discarded, the sutures are cut, and the mold is gently lifted out. The graft will appear as a layer of dead white epithelium which, when washed off, will reveal a pinkish area beneath. The mold is now cleansed, greased, and reinserted for another week, at which time it is replaced with one made of gutta percha. When all contraction has ceased—usually after 3 or 4 months—an artificial

shell is fitted into the newly lined cavity, the mold being used as a model Finally the canthotomy wound is closed, so that the two eyes will appear symmetrical

Goldstein (34) employs the following technic after exenteration of the orbit (fig 544). The orbital cavity is lined with a razor graft in the usual manner, and the remaining portions of the lids are turned into the orbit where they are allowed to adhere to the bone Six weeks later the adherent lids are freed, and the raw surfaces on the posterior part of the lid and on the denuded bone are covered with a skin graft. At a

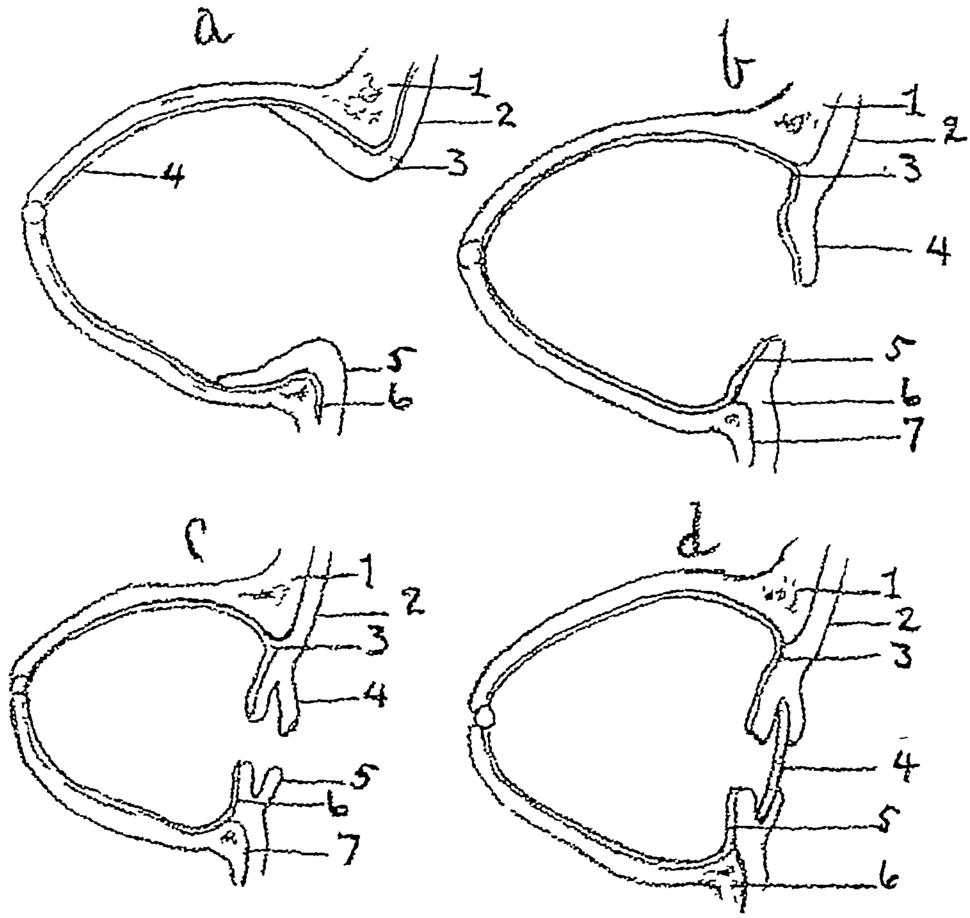


Fig 544 Goldstein operation following exenteration of orbit *a*, sectional view, showing orbita cavity lined with razor graft Lids turned into orbit and allowed to adhere to bone *1*, margin of orbit, *2*, brow, *3*, lid, *4*, Thiersch graft, *5*, lid, *6*, margin of orbit *b*, lids freed, and their posterior surfaces and denuded bone covered with razor graft *1*, margin of orbit, *2*, brow, *3*, Thiersch graft, *4*, lid, *5*, Thiersch graft, *6*, lid, *7*, margin of orbit *c*, lids slit along margins *1*, margin of orbit, *2*, brow, *3*, Thiersch graft, *4*, lid split in two, *5*, Thiersch graft, *6*, lid split in two, *7*, margin of orbit. *d*, raw surfaces covered with razor graft on dental mold *1*, margin of orbit, *2*, brow, *3*, Thiersch graft, *4*, artificial eye, *5*, Thiersch graft, *6*, margin of orbit For details, see text

third operation 3 weeks later the lids are slit along their margins from the inner to the outer canthus, the dissection being extended above and below to the margins of the orbit Into each sulcus thus formed a dental mold 1 mm thick, 15 mm wide, and 50 mm long, covered with a razor graft, is introduced and kept in position by uniting the 2 laminae over them Immobilization is secured by means of gauze packed into the orbit and the application of a pressure dressing

Following enucleation of the eyeball the orbital cavity may fail to furnish sufficient support for an artificial eye In such cases the floor and muscle cone of the socket

must be built up by some form of implant. The most desirable material for implantation along the floor of the orbit is fascia lata. For filling inside the muscle cone different substances, such as fascia, cartilage, bone, fat, etc, may be employed. Wheeler (84) advocated the use of grooved spheres of glass, each groove being so arranged as to receive one of the 4 rectus muscles. He operated essentially as follows (fig 545) Anesthesia is secured by avertin or by avertin and ether inhalation The socket is exposed with a speculum, and a horizontal incision is made through the conjunctiva behind the palpebral fissure (fig 545-a) The membrane is dissected from Tenon's capsule and is caught between the blades of the speculum holding the lids. A vertical

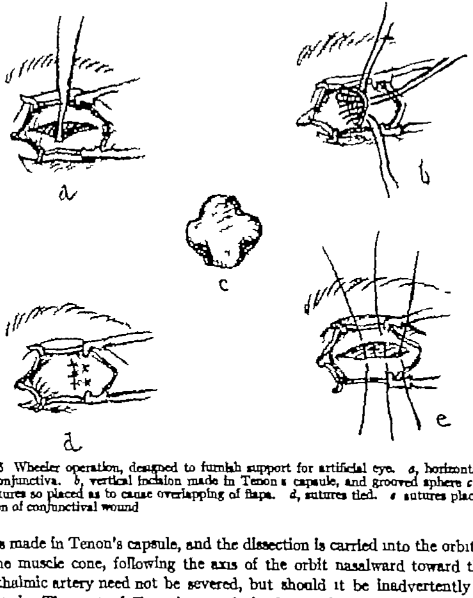


FIG 545 Wheeler operation, designed to furnish support for artificial eye. *a*, horizontal incision made in conjunctiva. *b*, vertical incision made in Tenon's capsule, and grooved sphere *c* placed in orbit. Sutures so placed as to cause overlapping of flaps. *d*, sutures tied. *e* sutures placed for approximation of conjunctival wound

incision is made in Tenon's capsule, and the dissection is carried into the orbital tissue within the muscle cone, following the axis of the orbit nasalward toward the apex. The ophthalmic artery need not be severed, but should it be inadvertently injured, it is ligated. The mat of Tenon's capsule is dissected up for a few millimeters on each side of the vertical incision, and the grooved glass sphere is inserted into the newly formed cavity within the muscle cone. The direction of the grooves in the implant should be such that the 4 rectus muscles will fit into them. Mattress-sutures of fine chromic catgut are placed in Tenon's capsule in such a manner that there will be an overlapping of the flaps of 4 to 5 mm. (fig 545 b, d) The conjunctival flaps are

then released from the blades of the speculum, and the conjunctival wound is closed with fine silk (fig 545-e) Finally, a pressure dressing is applied and left in place for a week. The conjunctival sutures are removed at the time of the first dressing, at which period a lighter dressing is applied and worn for a few days The socket is ready to receive the prosthesis 3 weeks after operation.

Following a complete loss of both the orbital contents and the eyelids the cavity which remains must be obliterated For this purpose a temporal flap may be carried into the orbit through a vertical incision in the outer canthus and sutured to the surrounding structures (35) (fig 546-a, b), or a forehead flap may be utilized for the same purpose (52) (fig. 546-c) Davis (17) implants a flap of skin carrying a thick layer of fat from the abdomen, and uses the hand as an intermediate carrier His technic is as follows: An abdominal flap is sutured into an incision in the palm of the hand, and after vascularization has taken place, the pedicle attached to the abdomen is cut, and the flap is introduced into the revivified orbital cavity, where it is held in place

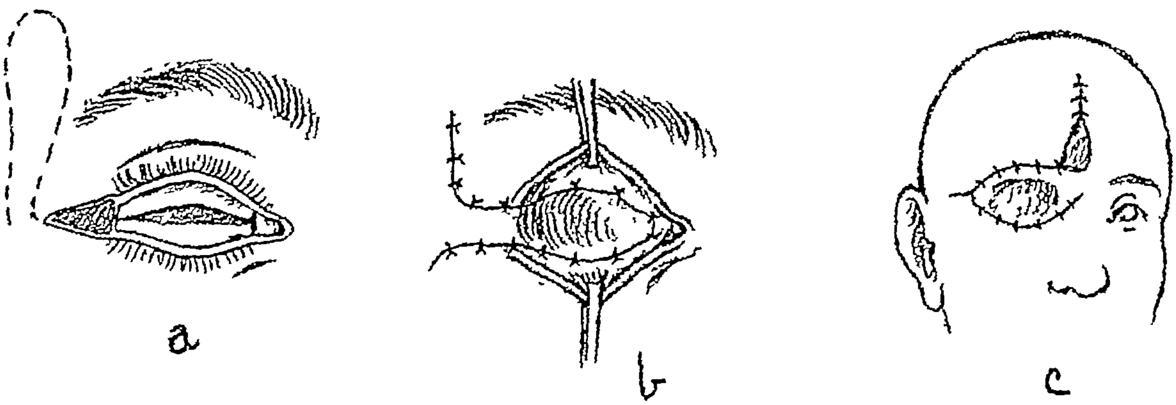


FIG 546 Obliteration of orbital cavity following loss of orbital contents *a-b*, by temporal flap *a*, flap outlined *b*, flap swung into defect and sutured in place (Golovine) *c*, by forehead flap Secondary defect on forehead closed as far as possible, and remaining area covered with skin graft. (von Kuester)

by fixing the hand to the head After the nutrition of the flap is assured, the hand is released and the balance of the flap sutured in place

TUMORS OF EYELIDS AND ORBIT

Benign tumors are of common occurrence in the eyelids, and the variety known as *papillomata* are among those most frequently encountered They are prone to occur in individuals beyond middle life and assume the form of a single pedunculated warty growth on the margin of the lid Microscopically, they reveal an overgrowth of epithelium and connective tissue *Fibromata*, likewise, often appear near the margin of the lid and manifest themselves as yellow elevated nodules resting on a broad base *Dermoids*, also, may be encountered, either in a simple form lined with epithelium, or in a complex form carrying mesodermic structures *Hemangiomata* and *nevi* of the lids are common and do not differ from those in other parts of the face They are discussed in detail in Chapter XIX. *Xanthelasmata* appear as one or more flat, yellow, slightly elevated patches, usually located on the nasal side of the lid They are due to a fatty degeneration of the dermis and are seen most commonly in women after the menopause Histologically, they are composed of connective tissue filled with

fat globules. Like all benign tumors, they show no tendency to recur after removal. Sebaceous and sudoriferous *cysts* are also frequently found in this locality

A *chalazion* is a retention cyst of a meibomian gland. These cysts are more often seen in the upper than in the lower lid They seldom undergo inflammatory changes or cause discomfort. They may be excised through an intermarginal incision, or through an incision in the conjunctival surface of the lid, as follows With the lid everted by means of a ring lid forceps, an incision 6 mm. long is made through the conjunctival surface, and the mass is removed with its capsule intact. In cases of long standing this may be impossible, however, and under such circumstances the mass must be curetted out (fig 547)

Malignant tumors of the lid are comparatively rare and usually take the form of *carcinomata*, appearing, as a rule, near the inner canthus. Their management is discussed on page 1336

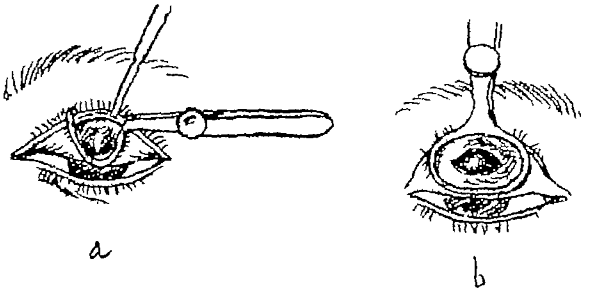


FIG. 547 Removal of chalazion. *a*, through intermarginal incision. *b* through conjunctival incision.

Tumors of the orbit do not differ from those occurring in other bones of the face and are discussed on page 992 They may be benign or malignant. Of the benign growths the most common are *osteomata*, *lipomata* *angiomata*, *polypi*, *orbital cysts*, and *encephaloceles* They have a predilection for the upper and inner walls of the cavity They may originate in the orbit itself or extend into it from the nasal fossa, base of the skull, maxillary antrum temporal fossa, or zygomatic fossa. In the latter case they either penetrate the intervening thin lamina of bone or pass through the orbital apertures—namely, the optic foramen, superior orbital fissure, inferior orbital fissure, and nasolacrimal duct. Due to the looseness of the tissues in the orbit, these growths may attain a considerable size without producing symptoms, but eventually the eyelids become swollen and the eyeball displaced, the direction of displacement depending upon the location of the tumor If it lies near the optic foramen, the eye is pushed forward If situated in other parts of the orbital cavity, the eye will be shifted to one or the other side.

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CHAPTER XIII

THE AURICLE

ANATOMIC CONSIDERATIONS

The auricle, situated between the temporomaxillary articulation in front and the mastoid process behind, projects from the side of the head at an angle of 30 degrees Its form, except at the lobule, is maintained by a thin, flexible framework of yellow elastic fibrocartilage The ligaments are divided into an extrinsic set which anchor the auricle to the temporal bone, and an intrinsic set which hold the cartilage in position The muscles are rudimentary and of no surgical importance The skin is thin and is adherent to the cartilage, except on its posterior surface and along the convexity of the helix

The anterior surface of the auricle is irregularly concave and shows the following structures (fig 548). (1) The *helix*, the folded outer rim, which begins at the crus helicis in the concha and ends in the dependent lobule. Below and behind the top of the ear is its morphologic apex, evidenced by a rudimentary projection called Darwin's tubercle (2) The *anthelix*, a prominent semicircular curve in front of the helix, bifurcating above to form the crura anthelicis which enclose the fossa of the anthelix (3) The *scaphoid fossa* (fossa of the helix), an elongated depression between the helix and the anthelix (4) The *concha*, a funnel-shaped cavity leading to the auditory canal (5) The *crus of the helix*, an oblique ridge dividing the concha into the cymba conchae above and the cavum conchae below (6) The *tragus*, a prominence in front of the concha, projecting backward over the meatus (7) The *antitragus*, a prominence opposite the tragus and separated from it by the incisura intertragica (8) The *lobule*, the most dependent part of the auricle, composed of skin, fat, and fibrous tissue. According to Schwalbe, the normal range in the length of the auricle in the male is from 50 to 82 mm , and in the female from 50 to 75 mm , in width it varies from 32 to 52 mm in the male, and from 28 to 45 mm in the female

The arterial supply of the auricle is derived from the posterior auricular branch of the external carotid artery, the anterior auricular branch of the temporal, and the auricular branch of the occipital The veins follow the same course as the arteries The lymphatics empty into the periauricular glands The nerve supply is derived from the great auricular branch of the cervical plexus, the auricular branch of the vagus, the auriculotemporal branch of the inferior maxillary, the small occipital, the great occipital, and several branches of the facial (fig 549)

WOUND ... RI

Wounds of the auricle are treat ... surgical principles (Chapter III). Owing to the g ... s heal readily, and for this reason all t ... gments

which have been partially torn loose should be carefully cleansed and sutured back into place, regardless of the slenderness of their pedicles. Even completely severed parts,

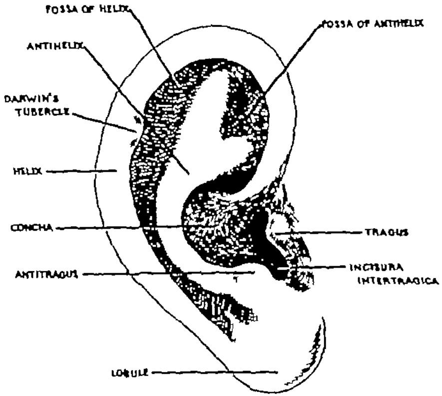


Fig 548. Anterior aspect of auricle.

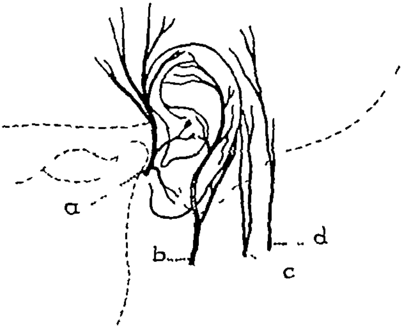


Fig 549 Sensory nerve supply of auricle *a* auriculotemporal nerve *b* great auricular *c* mastoid branch of small occipital, *d* small occipital. (Labat)

when clean can be replaced with a fair chance that union will follow Conservation of tissue is especially important in wounds about the external auditory meatus, in order

that the danger of stenosis may be averted If the skin around the meatus has been entirely destroyed and the condition of the raw area warrants, it should be immediately covered with a skin graft Fractured cartilages must be carefully reduced and immobilized by means of silk sutures passed through the perichondrium. Hematomata are treated by the application of cold compresses If at the end of 24 hours absorption has failed to take place, the liquid should be aspirated with a syringe or drainage provided through an incision made along the fossa of the helix, in order to prevent infection and osteochondromatous changes which may give rise to a cauliflower ear

After the wound has been properly cleansed, it is closed by means of a primary suture, the stitches being placed far enough apart to permit of the escape of serum and blood To prevent distortion or collapse, the ear is dressed with a compression bandage consisting of 2 or 3 layers of xeroform gauze overlaid by a damp marine sponge which under pressure will conform to the convolutions of the part and when hardened will serve as a splint Britton (9) fits a piece of #18 copper wire covered with adhesive

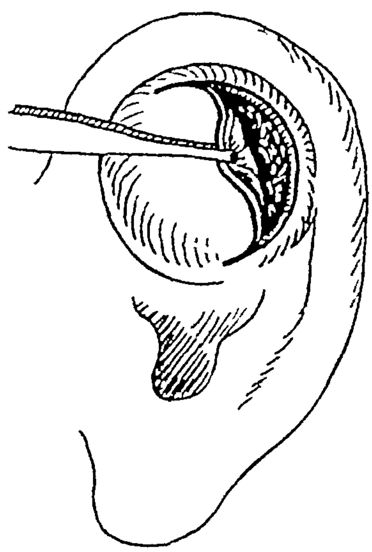


FIG 550 Use of skin-perichondrial flap raised from anterior surface of auricle, for excision of osteochondromatous tissue in cauliflower ear (Lautenschlaeger)

tape into the fossa of the helix and fills the anterior irregular surface with plaster of Paris or cotton saturated with collodion Palmer (44) inserts into the wound a eustachain catheter to which a pump is attached, places a frame around the ear, and fills it with plaster of Paris until the entire auricle is completely enclosed As the plaster hardens, the pump is operated, thereby removing the accumulated blood and at the same time causing approximation of the skin to the cartilage by suction Throughout the process the catheter is kept in constant rotation to facilitate its removal Following its withdrawal the tract remaining will serve for purposes of drainage After 10 days the plaster cast is removed by fragmentation

A not infrequent result of repeated traumatisms is the deformity known as *cauliflower ear* (fig 571-h), commonly seen in pugilists, wrestlers, and football players The condition is due either to the organization of a blood-clot beneath the skin or perichondrium, or to a traumatic chondritis In either case osteochondromatous changes take place, and the ear becomes thickened and misshapen, resembling a cauliflower Correction of this deformity may be accomplished as follows: A flap composed of

skin and perichondrium is raised either on the anterior or posterior surface of the auricle, depending upon the location of the pathologic tissue (fig 550) The osteochondromatous masses thus exposed are shaved, curetted or chiseled away, until the ear approximates the normal shape. The flap is then sutured back into place, and a dressing is applied which will assure even pressure and prevent the reaccumulation of blood and serum Moist cotton pledgets or a dampened marine sponge packed snugly against the convolutions of the ear and held in place by means of a bandage will serve the purpose.

RECONSTRUCTIVE PROCEDURES

Operations on the auricle are undertaken for the correction of congenital errors in size, position, and shape, for the repair of acquired cicatricial deformities, and for the replacement of losses resulting from burns and other traumatisms. Congenital defects vary from a slight alteration in the shape of the ear to total absence their extent depending upon the embryonic stage at which development was arrested (fig 571)

The correction of auricular deformities requiring merely a reduction in size or a change in shape or position is comparatively simple, but the restoration of a partial or complete loss remains the most difficult of all reconstructive operations. Even with the utmost ingenuity on the part of the surgeon it is practically impossible to reproduce the natural contour, color, size, and projection angle Thus Beck (4) states "The great difficulty is to obtain a good cosmetic result when the external ear is more than two-thirds absent. Surgery, however, has not proved equal to the task The long, tedious multiple procedures do not produce results that are esthetically acceptable and only serve to substitute monstrosity for deformity"

The difficulty lies chiefly in the lack of suitable replacement material. The thinness, texture, and color of auricular skin is unlike that in any other part of the body and cannot be duplicated, and ear cartilage is comparable only to that found in the nose and the fellow ear While cartilage from these localities serves as a satisfactory substitute, the amount available is insufficient except for the repair of small losses. In the case of large defects recourse must be had to rib cartilage, but this material, unfortunately, is unsuitable Even though it can be modeled to conform to the intricate structure of the ear skeleton, the thinness to which it must be reduced destroys its property as a supporting structure and causes it to curl out of shape This difficulty has led to experimentation with many forms of heterogenous substances. Foreign body supports of all kinds have been tried but have proven unsatisfactory Recently, however isografts obtained from the maternal aural cartilage (41) have been used with success.

Owing to the generally disappointing results following reconstructive operations on the auricle, the problem until recent years has been evaded by recourse to prosthetic appliances of gelatin papier-mâché, celluloid, rubber metal, and other materials, shaped and colored to match the normal ear and anchored in place by mastisol, fine spring bands passing over the top of the head, expanding springs placed in the external auditory canal or surgically constructed pockets. With the recently aroused interest in reconstructive operations in general, the surgery of the auricle has been greatly improved, and the results are becoming more and more acceptable (31, 35, 39, 51) While

such reconstructions still fall short of complete perfection, nevertheless the majority of patients with auricular deficiencies prefer an autoplastic replacement to an artificial contrivance, however perfect in appearance the latter may be

Preoperative Considerations

Before a reparative operation on the ear is undertaken, a careful analysis of the deformity is particularly important, since not infrequently the nature of the malformation is misleading, and surgery based on an incorrect diagnosis may materially exaggerate the defect For instance, an ear may appear to be unusually large, owing to an abnormal projection of the angle or an obliteration of its natural folds In such a case a closer approximation of the ear to the skull or a procedure designed to reconstruct the folds will be all that is necessary to efface the illusion Obviously, a reduction in the size of such an ear would only serve to create another disfigurement

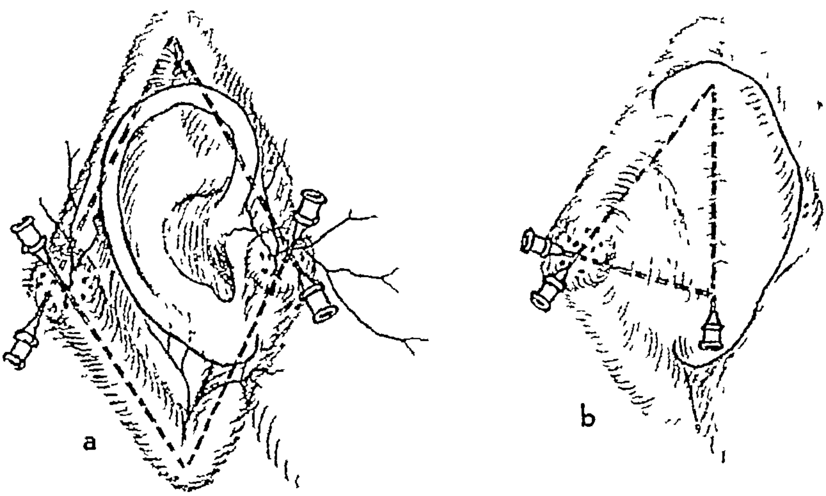


Fig 551 Local anesthetization of auricle *a*, circular block through 2 epidermal wheals *b*, line of incision and plane of dissection infiltrated

The operation should be so planned that at its completion the two ears will be symmetrical in size, shape, and position This can be accomplished most conveniently if both ears are corrected at the same sitting Should two or more deformities exist, however, the operation had best be carried out in stages For instance, in the case of large outstanding ears the repositioning should constitute one stage and the diminution in size another Operations designed for the replacement of lost tissues often require many stages with long intervals between to allow for shrinkage and readjustment.

In all operations about the ear healing by first intention is essential, since delayed repair predisposes to keloid formation which is apt to defeat the purpose of the reconstruction Therefore, rigid asepsis and careful hemostasis are of the utmost importance The cartilage must be handled gently, inasmuch as its poor blood supply renders it subject to infection and chondritis, and the margins should be trimmed evenly, since any irregularity will show beneath the skin

Anesthesia is obtained by nerve blocking (fig 551) or by infiltration with 1 to 2 per cent procain to which have been added 5 or 6 drops of epinephrin (1:1000) to the ounce A fine short needle is introduced beneath the skin of the retro-auricular region, and the

line of incision and plane of dissection are infiltrated. The introduction of a few drops of the anesthetic solution between the skin and cartilage on the anterior surface of the ear will separate the tissues and thus assist in the dissection. The external auditory canal is plugged and the parts are aseptically prepared and draped in the customary manner

Errors in Position

Outstanding Ears

The outstanding ear deformity may be unilateral or bilateral and is due to an unusually wide angle between the concha and the mastoid process, the distance being at times so great as to cause the ears to stand out at right angles from the head. The abnormality may be only apparent, as the result of excessive size or alteration in the shape of the auricle. In such cases correction of the latter defects will dispel the illusion of projection. The following discussion applies only to ears of normal size and shape which project from the head at an angle of more than 30 degrees.

Attempts to correct outstanding ears by means of compression bandages, elastic caps, adhesive strapping, ear muffs, etc., even in infancy, are futile, since the elastic recoil of the cartilages will inevitably cause a reappearance of the deformity The only measure of permanent value is the reduction of the size of the angle by the removal of a crescent-shaped section of postauricular skin and cartilage, followed by incisions designed to break the spring of the remaining cartilage

The amount of tissue to be removed can be determined as follows The patient is seated in front of a mirror and his ears pressed back until the desired angle is obtained. The line of contact between the ear and the head is then outlined in a dye, such as methylene blue, or the skin on the back of the auricle along its line of contact with the head is scratched with the point of a scalpel and the bleeding line pressed against the mastoid process. When the auricle is permitted to spring back into its former position, two ovals will be outlined either in dye or blood, one on the back of the auricle and the other on the mastoid process.

Davis and Kitlowski's (13) method of securing orientation for the position of a proposed anthelix can also be utilized in gauging the amount of skin and cartilage to be excised in the case of outstanding ears (fig 552) "An hypodermic needle, at least one inch long and about 24 gauge, dipped in brilliant green solution and placed at right angles to the anterior skin surface is thrust completely through the ear from front to back, coming out at a corresponding skin point on the posterior surface When the needle emerges through the skin of the back of the ear, its point is touched with a tooth pick swab dipped in the same solution, before it is drawn back again, and in this way sufficient dye is carried through the tissues to make the required marks on the cartilage but not enough to overstain, as would be the case if there were dye in the needle or syringe. A green puncture mark shows on the skin of the anterior surface of the ear where the needles enter and similar marks are found on the skin of the posterior surface of the ear where the needles emerge The ear is drawn forward, the puncture marks on the back of the ear are connected by a line of brilliant green applied with a toothpick, and this line while damp is pressed against the skin of the scalp with the ear in normal position. This gives a slight greenish mark which is supplemented to make it more

distinct, and the area inside these lines, which when the ends are extended and joined is more or less elliptical in shape will be the skin area to be excised "

Many operations have been suggested for the correction of outstanding ears They may be grouped into those which attempt to overcome the condition by (1) excision merely of a section of skin from the retro-auricular angle, (2) excision of skin combined with incisions into the cartilage or excision of cartilage strips, and (3) fixation of the auricle to the mastoid process

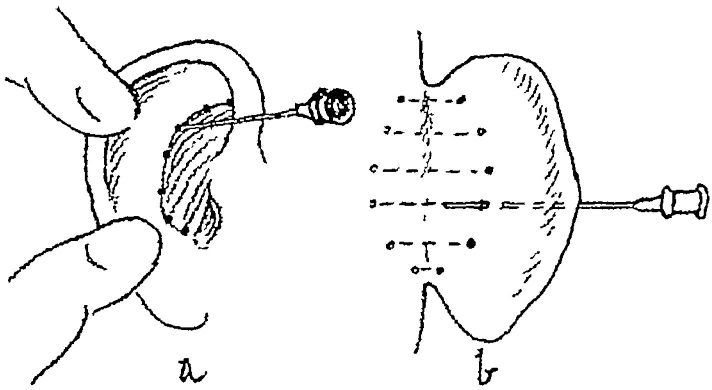


FIG 552 Method of determining amount of tissue to be removed, to reposition outstanding ear *a*, ear held in normal position, and line of contact marked out with hypodermic needle dipped in brilliant green *b*, posterior view For details, see text (Davis and Kitlowski)

FIG 553 Repositioning of outstanding ear by approximation of wound margins following skin excision from cephalo-auricular angle Dotted line indicates area of skin to be removed (This operation is applicable only when the cartilage is exceptionally flexible)

(1) **Skin Excision.** The mere excision of a strip of retro-auricular skin, except in cases where the cartilage is exceptionally flexible, is unsatisfactory, since the skin tension thus obtained is not sufficient to prevent the elastic recoil of the cartilage

The steps of the operative procedure are as follows (fig 553): The ears are positioned at their proper projection angles and the line of contact marked out on the auricle and on the mastoid process Skin incisions are made along these lines and joined above and below. The intervening cordiform section of skin is removed Bleeding is controlled by pressure or ligation Silk sutures are passed through the skin margin of the auricle and through corresponding points in the skin over the mastoid process These sutures when tied will serve to close the wound and reposition the ear in its normal location To obliterate dead spaces, the skin over the *retro-auricular angle* is

tacked down to the underlying structures by means of a few silk mattress-sutures. A rubber drain is then inserted, to be removed in 24 hours. The wound is dressed with silver foil or xeroform gauze over which a few layers of dry gauze are superimposed, the whole held in place by the sutures previously passed and left long for the purpose. A circular pressure bandage is applied and left in place for a week, at which time the

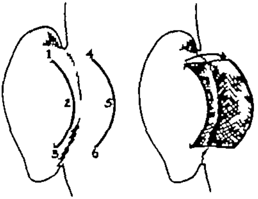


FIG. 554. Repositioning of outstanding ear by attaching flap of posterior auricular skin to mastoid process. Skin to be excised outlined by incisions *1–3* and *4–6*. *Flap 2 undermined to dotted line and sutured to wound margin on mastoid process* (Ruttin)

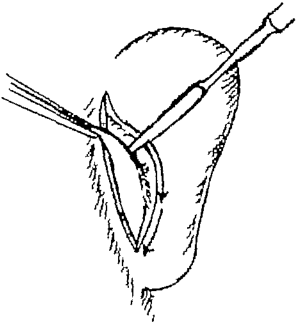


FIG. 555 *Reduction of outstanding ear by excision of oval section of skin and cartilage from cephalo-*auricular angle, anterior auricular skin being left intact. Spring of remaining cartilage destroyed by extension of cartilage wound above and below. Ear set back and wound margins sutured in layers, perichondrium with fine catgut, and skin with subcuticular suture of silk. (This procedure insures permanent results, but it causes wrinkling of the anterior auricular skin.)

sutures are removed. The patient is instructed to wear an elastic cap at night for several weeks thereafter.

Ruttin (55) excises a section of skin from the retro-auricular angle, as illustrated in Figure 554, and, after undermining the margin of the auricular wound, unites the flap thus formed to the wound margin on the mastoid process.

(2) **Skin and Cartilage Excisions.** As has been said before, the removal of a section

of skin and cartilage from the retro-auricular angle offers the most satisfactory solution to the problem of the outstanding ear (fig 562)

After the excision of a cordiform section of skin from the mastoid process and posterior surface of the auricle, an oval segment of cartilage of a size sufficient to bring about the required reduction in the angle and with its long axis parallel to that of the

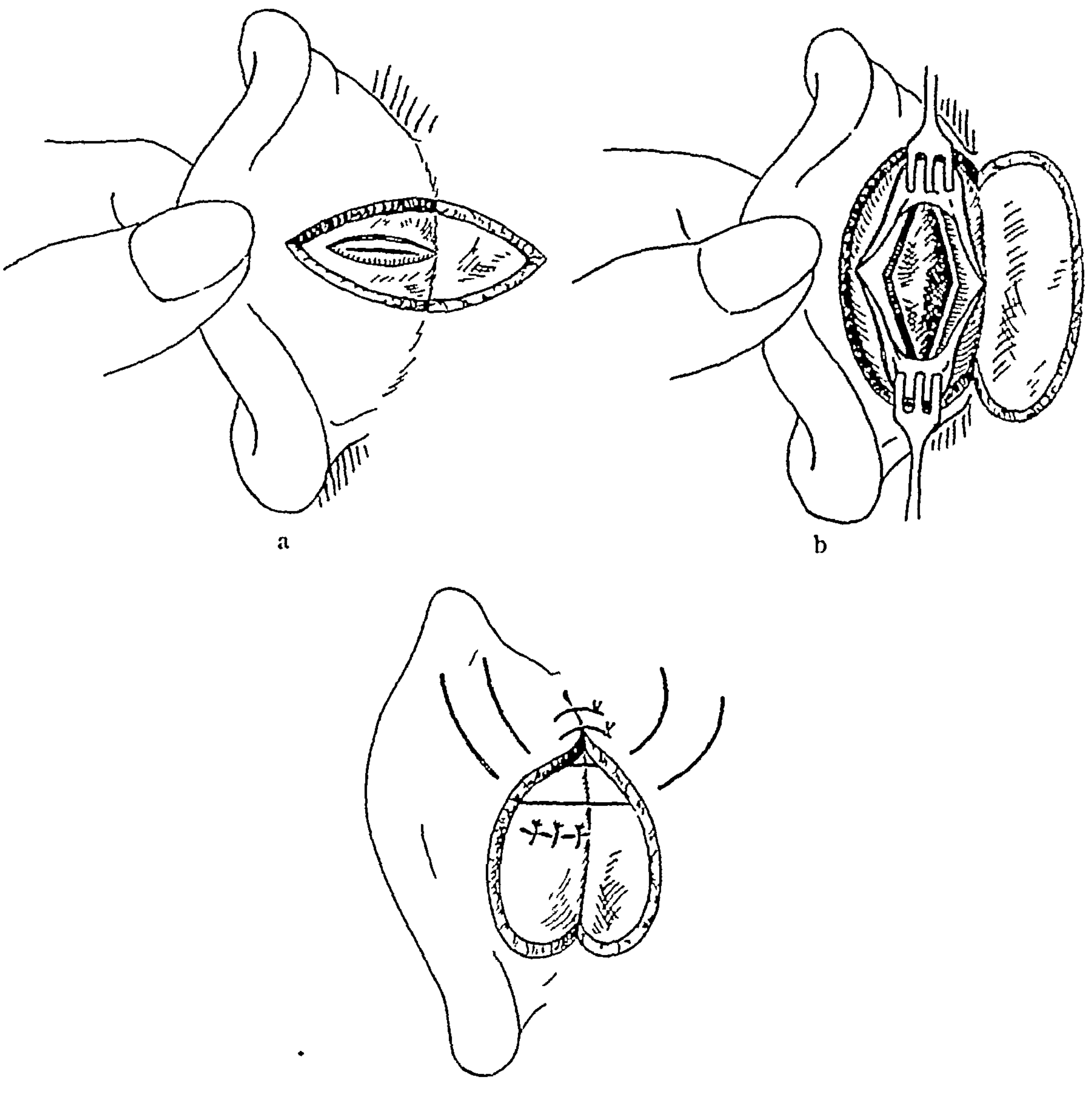


FIG 556 Eitner operation for correction of outstanding ear *a*, cartilage exposed through horizontal incision over back of ear and mastoid process, to avoid injury to posterior auricular artery Skin retracted, and perichondrium and cartilage incised horizontally *b*, perichondrium retracted, and 2 triangles of cartilage with common base removed, size depending upon desired reduction Excess skin excised *c*, perichondrium united, skin margins approximated

ear is removed, care being taken not to perforate the anterior skin (fig 555) Such an accident can be averted if a finger is held against the skin on the anterior surface of the concha while the section is being excised The spring of the remaining cartilage is destroyed by an extension of the apices of the oval wound in the cartilage above and below. The skin margins are then approximated with on-end mattress-sutures, or by a continuous subcuticular suture of fine silk. A silkworm-gut drain is inserted into

the lower angle of the wound. The suture line is covered with a sheet of tinfoil or with 2 or 3 strips of 4 per cent xeroform ointment gauze, and the convolutions of the ear are carefully packed with moistened cotton tampons. Over the auricle are placed several layers of gauze, and a circular bandage incorporating a marine sponge is snugly applied. The head bandage should be sufficiently taut to control oozing but not so tight as to endanger the nutrition of the skin or cartilage The drain is removed after 24 hours and the sutures within 8 to 10 days, after which time the patient is instructed to wear a bandage at night for 2 or 3 weeks.

While the foregoing procedure successfully corrects the deformity, it leaves an ugly wrinkling of the skin on the anterior surface of the ear Eitner (19) devised the following operation to overcome this objectionable feature (fig 556) After the desired position of the ears has been marked out, the cartilage is exposed through a horizontal skin incision made between the widest points of the outlined ovals on the back of the ear

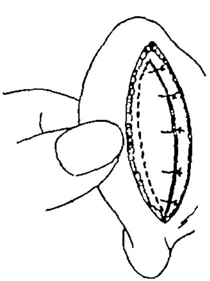


FIG 557 Correction of outstanding ear without sacrifice of cartilage. Arched longitudinal incision made through skin and cartilage on posterior auricular aspect. Anterior auricular skin undermined 8 mm. Lateral edge of divided cartilage pushed behind medial edge, maintained in place with catgut sutures and anchored to postauricular fascia Redundant skin excised, and wound margins approximated (Alexander)

and the mastoid process, thereby doing away with the danger of injury to the posterior auricular artery (fig 556-a) The skin is undermined and retracted upward and downward to expose the perichondrium of the auricle and the periosteum of the mastoid process. The perichondrium is then incised horizontally, separated from the underlying cartilage, and retracted in a similar manner The cartilage thus exposed is divided horizontally and through this incision it is bluntly separated from its anterior skin attachment. Two triangles of cartilage with their bases on the horizontal line of the cartilaginous incision and their apices reaching the upper and lower poles of the concha are then removed (fig 556-b) The width of the bases will be determined by the desired reduction in the angle. The cordiform section of skin previously outlined on the ear and mastoid process is excised. The margins of the perichondrium are united horizontally with 1 or 2 fine catgut sutures (fig 556-c) To obliterate dead spaces, the perichondrium is tacked down to the periosteum of the mastoid process with fine catgut. Finally the two raw surfaces on the back of the ear and mastoid

process are approximated with silk and a pressure bandage applied The sutures are removed after 14 days

Alexander (1) reduces the angle without the sacrifice of cartilage by incision of the cartilage and imbrication of the edges as follows (fig 557). An arched skin incision with its convexity toward the helix is made on the back of the ear. The skin on both sides of the incision is undermined for 6 to 8 mm and retracted An arched longitudinal incision with its convexity toward the mastoid process is then made through the perichondrium and cartilage. Through the latter incision the skin on the anterior surface of the auricle is bluntly separated from the cartilage for about 8 mm along its lateral margin The lateral edge of the cartilage is pushed behind the medial edge and maintained in this position by means of a few #0000 chromic catgut sutures passed through the perichondrium The cartilage is then anchored to the postauricular fascia with 2 or 3 sutures Finally, the redundant skin on the back of the ear, formed as

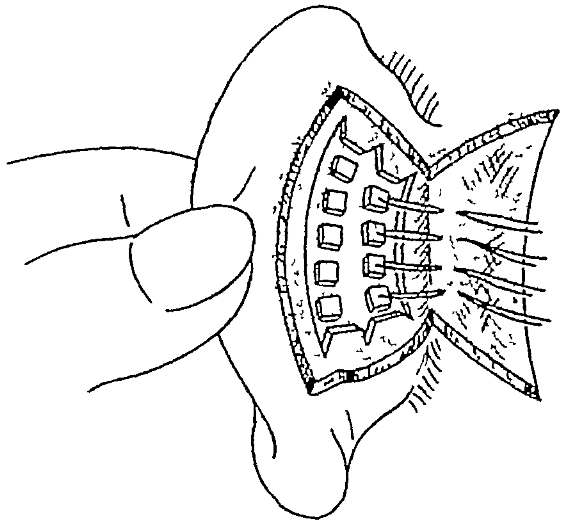


FIG 558 Gersuny operation for correction of outstanding ear Skin flap, pedicled on mastoid process, turned back Two or 3 vertical strips of cartilage removed, and balance sectioned transversely. Perichondrium of auricle sutured to periosteum over mastoid process, and skin flap replaced

a result of the overlapping of the cartilages, is removed, the skin edges approximated, and a dressing applied.

Gersuny (25) employed a somewhat similar procedure (fig 558): A skin flap with its pedicle on the mastoid process is raised on the posterior aspect of the ear and turned back to expose the cartilage The cartilage is split longitudinally into ribbons, and 2 or 3 narrow strips are removed Several transverse excisions are then made which give the cartilage the appearance of a checkerboard. The spring of the cartilage being thus broken, the auricle is now placed in the desired position and maintained by the attachment of the perichondrium to the periosteum of the mastoid process The skin flap is then replaced and a dressing applied

(3) **Fixation of Auricle to Mastoid Process** Reduction of the outstanding ear by its fixation to the mastoid process was advocated by Payr (50), Demel (11), Feigl (15), Luthi (40), and others, but on the whole these procedures are unnecessarily complicated Demel's (14) operation, here described, will explain the principle of the technic: After the excision of an oval-shaped section of skin, a flap of cartilage pedicled posteriorly is raised from the back of the ear, turned back, carried beneath a bridge of periosteum on the mastoid process, and sutured in place The skin wound is closed and a dressing applied Figures 559–560 are self-explanatory Ruttin (55) operates

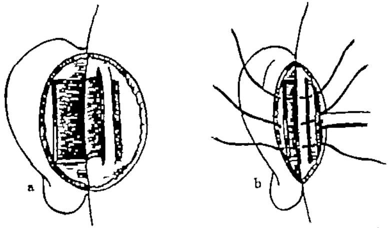


Fig 559 Correction of outstanding ear by auricular cartilage flap *a*, oval section of skin removed. Wide flap of auricular cartilage turned under bridge of periosteum on mastoid process *b* sutures placed. (Demel)

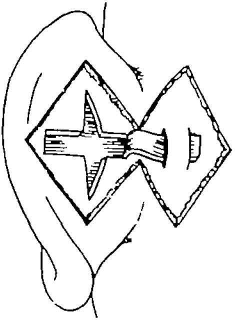


Fig 560 Correction of outstanding ear by auricular cartilage flap. Two diamond-shaped sections of skin removed from back of ear and mastoid process. Cartilage flap from concha turned back and fastened under bridge of periosteum on mastoid process. (Payr)

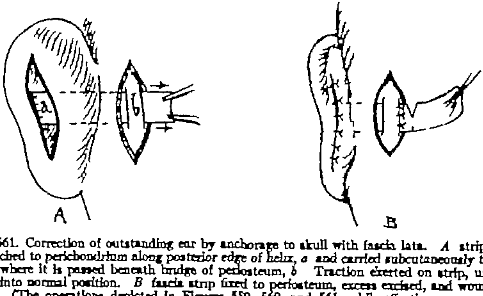


Fig 561. Correction of outstanding ear by anchorage to skull with fascia lata. *A* strip of fascia lata attached to perichondrium along posterior edge of helix, *a* and carried subcutaneously to mastoid process, where it is passed beneath bridge of periosteum, *b* Traction exerted on strip, until ear is brought into normal position. *B* fascia strip fixed to periosteum, excess excised, and wound closed. (Ruttin) (The operations depicted in Figures 559 560 and 561 while effective, are unnecessarily complicated.)

in a similar manner but carries the ear backward by means of a strip of fascia lata extending from the auricle to the mastoid process (fig. 561)

FIG. 562 Correction of outstanding ear by excision of skin and cartilage from cephalo auricular angle

Too Close Approximation of Ears to Head

A too close approximation of the ears to the skull may be due to a congenital diminution in the angle between the concha and mastoid process, but since in such cases both ears are usually involved and are identically positioned, the deformity is not sufficiently

conspicuous to require treatment. On the other hand, the flatness may be due to adherence of the auricle to the head following previous plastic operations, wounds, or burns, and since under these circumstances the defect is usually limited to one ear, the deformity is more marked and frequently requires correction. This is accomplished by separating the ear from the head and resurfacing the remaining raw area. If the surrounding skin is utilizable, an incision is made on the mastoid process following the curve of the helix and at a sufficient distance from it, so that the flap thus outlined may be turned in to form an epithelial cover for the back of the ear (fig 563) The raw surface remaining on the skull is covered with a split-skin graft which "takes" well because of the solid base afforded. But if, because of scarring or deficient blood supply the skin in the vicinity of the ear cannot be used to cover its posterior surface, correction may be accomplished by undermining the tissues beneath the ear and inserting into the pocket thus formed a skin graft on a mold, after the method of Esser (24) (fig 578) At the end of 10 days the pocket is opened, the mold removed, and the

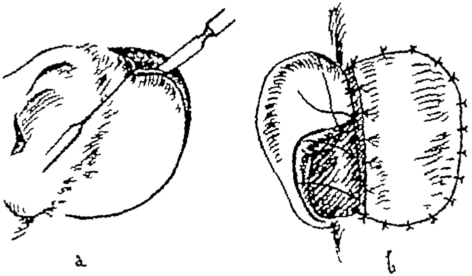


FIG. 563 Correction of adherent auricle. *a* skin flap outlined on mastoid process. *b* ear, together with attached flap, separated from skull. Flap turned back, to cover raw surface on posterior aspect of auricle. Secondary defect on mastoid process skin grafted.

ear separated from the head. The back of the ear and the mastoid process will be found covered with epithelium. Secondary minor modeling operations are usually necessary before the desired end result is attained.

ERRORS IN SIZE

Abnormally Large Ears (Macrotia)

The abnormally large ear may be unilateral or bilateral. All of its parts may be affected proportionately or the enlargement may be limited to certain areas. Records indicate that the first surgeon to attempt reduction of an abnormally large ear was Guiseppe de Martino (1856) Similar attempts were later made by Trendelenburg (62) (1886) Joseph (34) (1896), and Gersuny (25) (1903) Today it is a well-standardized operation. The reduction is accomplished by the excision of a triangular section from the entire thickness of the ear, the base of the triangle on the rim and the apex directed toward the meatus. Any difference in the length of the margins of the

resultant wound can be equalized by the removal from the concha of additional triangles with their bases on the line of the original incision (fig. 564)

Binnie (8) operated as follows (fig 565): A horizontal incision is made throughout the entire thickness of the auricle at its widest part The upper segment is pulled over the lower, until the desired reduction is attained, and the overlapping triangle is

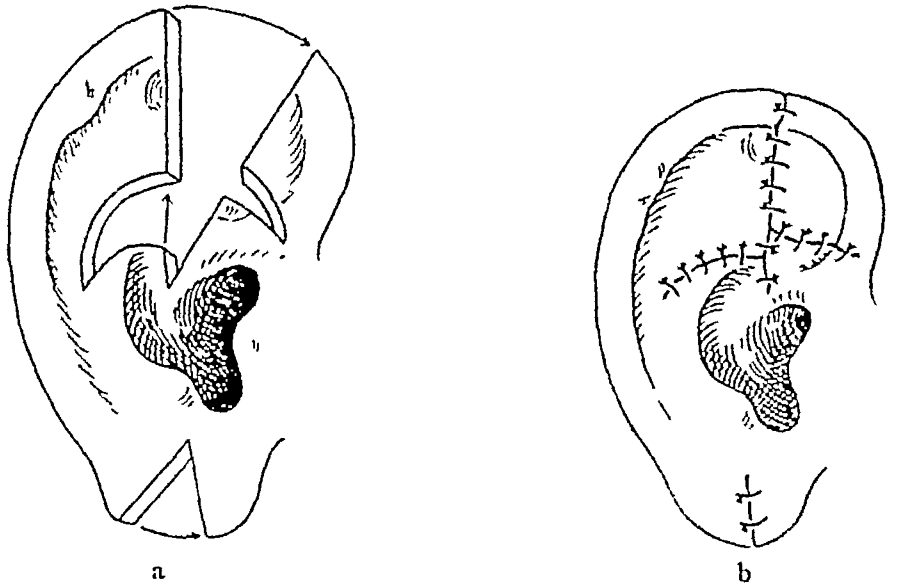


FIG 564 Reduction of abnormally large ear *a*, triangular sections excised from full thickness of ear, bases on rim and apices directed toward meatus. Margins of resultant wound equalized by semilunar or triangular excisions based on margins of incisions *b*, margins approximated (Trendelenburg)

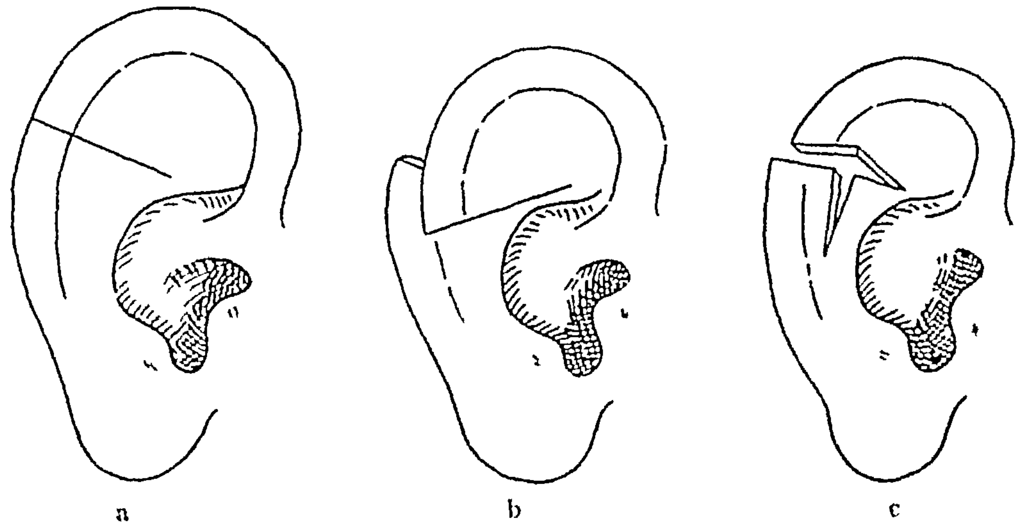


FIG 565 Reduction of abnormally large ear *a*, horizontal incision made through full thickness of auricle *b*, upper segment pulled over lower, until desired amount of reduction is attained Overlapping triangle of tissue removed *c*, triangular section excised from wide segment, to equalize apposing margins Margins of wound approximated in layers (Binnie)

removed After the excision it will be found that the lower segment projects beyond the upper, and to equalize the apposing margins a triangular section of tissue equal in width to the amount of reduction necessary is excised, its base on the cut margin and its apex directed downward The contiguous raw margins are united anteriorly and posteriorly, perichondrium to perichondrium and skin to skin

Trendelenburg (62) removed a triangle from the entire thickness of the ear, the base on the rim and the apex pointing toward the meatus (fig 564) The location of the base of the triangle is determined by the amount of reduction desired in the width and length of the auricle. If the ear is too long, but is of normal width, the base of the wedge is made to lie on the posterior margin. If, on the other hand, the ear is excessively wide but of normal length, the base is made to lie at the superior pole. To equalize the margins for approximation, 2 additional triangles are excised in the vicinity of the concha and the anthelix.

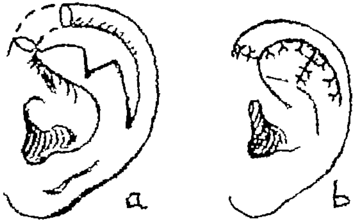


FIG. 566. Reduction of abnormally large ear a, helix divided near anterior attachment and separated from anthelix. Semilunar section removed from fossa of helix to reduce length, and triangular piece to reduce width. b, triangular defect closed in layers. Detached helix trimmed to fit reduced ear and sutured in place. (Kolle)

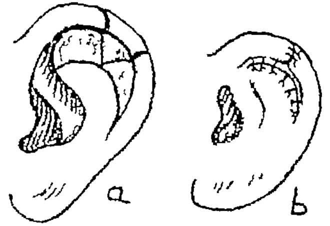


FIG. 567 Reduction of abnormally large ear a, triangle excised from full thickness of auricle. Crescentic section removed from fossa of helix. b parts readjusted and sutured in layers. (*Lexer*)

Kolle (38) and Lexer (39), in an effort to render the scar less conspicuous, divided the helix near its anterior attachment and separated it from the anthelix by an incision along the fossa of the helix (figs. 566-567) A semilunar section of the full thickness of the ear was then removed from the anthelix, to reduce the length and a triangular piece with its apex directed toward the meatus was excised, to diminish the width. The edges of the triangular defect were united in layers, perichondrium to perichondrium and skin to skin. The detached helix was then trimmed to fit the reduced ear and the margins approximated

Parkhill (46) cuts a triangular piece from the entire thickness of the auricle, the base lying on the upper part of the rim and the apex near the middle of the concha. A section of full thickness ear tissue, shaped like a half-ellipse and with its base on the margin of the triangular excision, is then removed from each side, the length and width

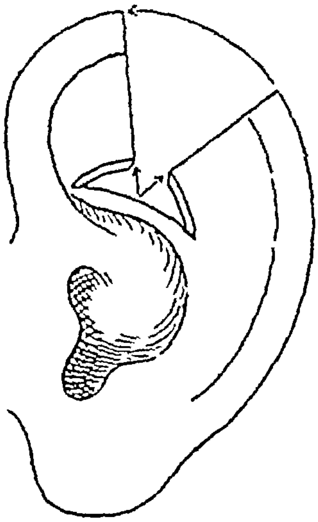


FIG 568 Reduction of abnormally large ear Triangle removed from full thickness of auricle, base on rim and apex directed toward meatus Two additional triangles excised from concha Wound margins coapted in layers (Parkhill) (The location of the base of the triangle to be excised is determined by the amount of reduction desired in the width and length of the auricle If the ear is too wide but of normal length, the base is placed at the superior pole of the ear, if too long but of normal width, the base is placed posteriorly)

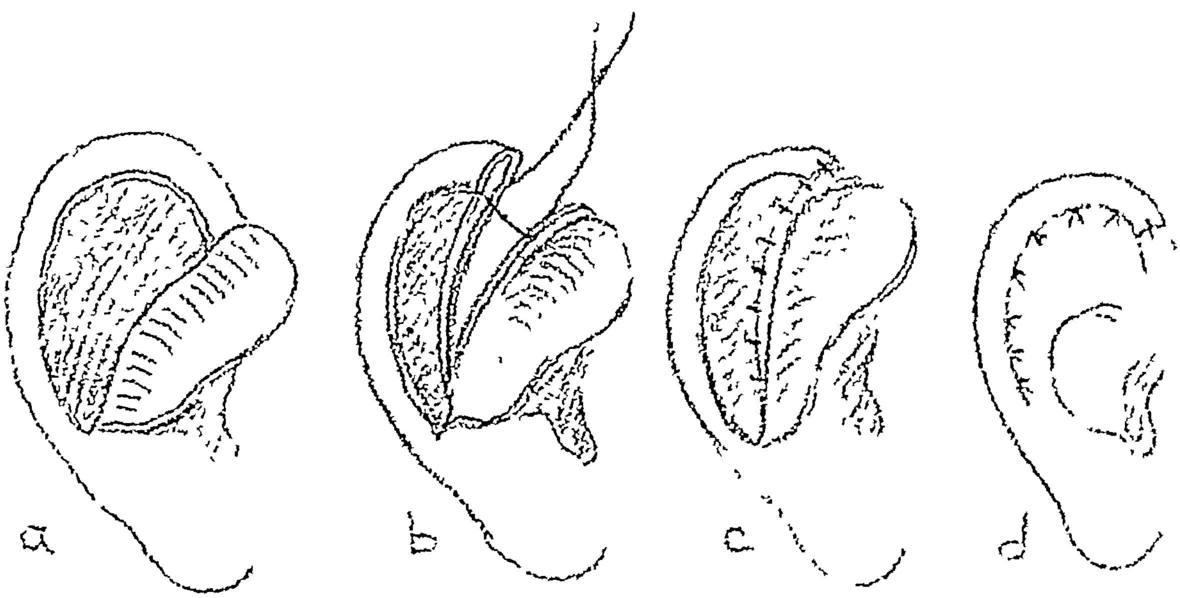


FIG 569 Subcutaneous reduction of abnormally large ear *a*, incision made along fossa of helix Anterior auricular skin dissected forward to anthelix *b*, sickle shaped segment of cartilage and post auricular skin of such size as to secure necessary reduction removed *c*, margins of resultant defect united in separate layers *d*, excess anterior auricular skin excised Skin margins approximated Surplus skin on back of auricle removed at another stage (Vogel)

of the section being so planned as to secure the desired reduction (fig 568) Following these excisions the edges of the wound thus created will tend to fall into apposition and are approximated in layers.

Vogel (61) reduces the size of the ear subcutaneously as follows (fig 569). An incision

beginning at the upper pole of the auricle is carried along the fossa of the helix encircling about ¾ of its length. The anterior auricular skin is dissected forward as far as the anthelix. A sickle-shaped section comprising cartilage and postauricular skin and corresponding in size to that of the desired reduction is then removed from the upper part of the auricle. The margins of the wound thus created are united in layers. The anterior auricular skin is drawn over the reduced ear, the excess is removed, and the margins are united. Since the resultant scar lies in the fossa of the helix, it is in conspicuous.

An abnormally large lobule may be reduced by the excision of 2 triangles, as indicated in Figure 570 (35) If the deformity is limited to excessive width, a triangle is excised from the full thickness of the lobule, its base at the lower pole and its apex directed upward. Abnormal length is reduced by the excision of a triangle with its base on the posterior margin of the lobule and its apex directed inward. Before undertaking

a b

FIG 570 Reduction of abnormally long lobule. *a*, triangle of full thickness of lobule removed Additional triangle excised from long side to equalize wound margins. *b* wound approximated in layers (Joseph)

the reduction of an enlarged lobule it is well to construct a paper pattern, in order to make certain that the calculations are correct and that the margins to be approxi mated will be of equal length.

Abnormally Small Ears (Microtia)

The method to be adopted for the correction of this condition will depend upon the nature of the deformity If the microtia is unilateral and not too pronounced, it may be advisable to reduce the size of the fellow ear or to graft a section from the larger ear into the smaller one and thus overcome the asymmetry If the condition is acquired as a result of cicatricial bands causing a distortion or rolling in of the ear, excision of the scar tissue, unrolling of the ear and skin-grafting of the raw surfaces may be all that is necessary

Errors in Shape

Errors in the shape of the ear are common and varied (fig 571) The upper part of the helix roll may be absent and the fossa of the helix obliterated in consequence,

the auricle appearing flattened and widened—triangular ear. The roll of the helix may be missing at its upper pole only, the auricle terminating in a point—pointed ear. All of the natural folds may be absent, the auricle resembling a hollow shell attached to the head—shell ear The cartilage may lack resiliency, or the folds which normally help to maintain the upright position of the auricle may be wanting, causing the ear to bend over upon itself—lop ear

Triangular Ears

The roll of the helix may be restored by the removal of a crescent-shaped section composed of cartilage and anterior auricular skin from the flattened area, the skin on

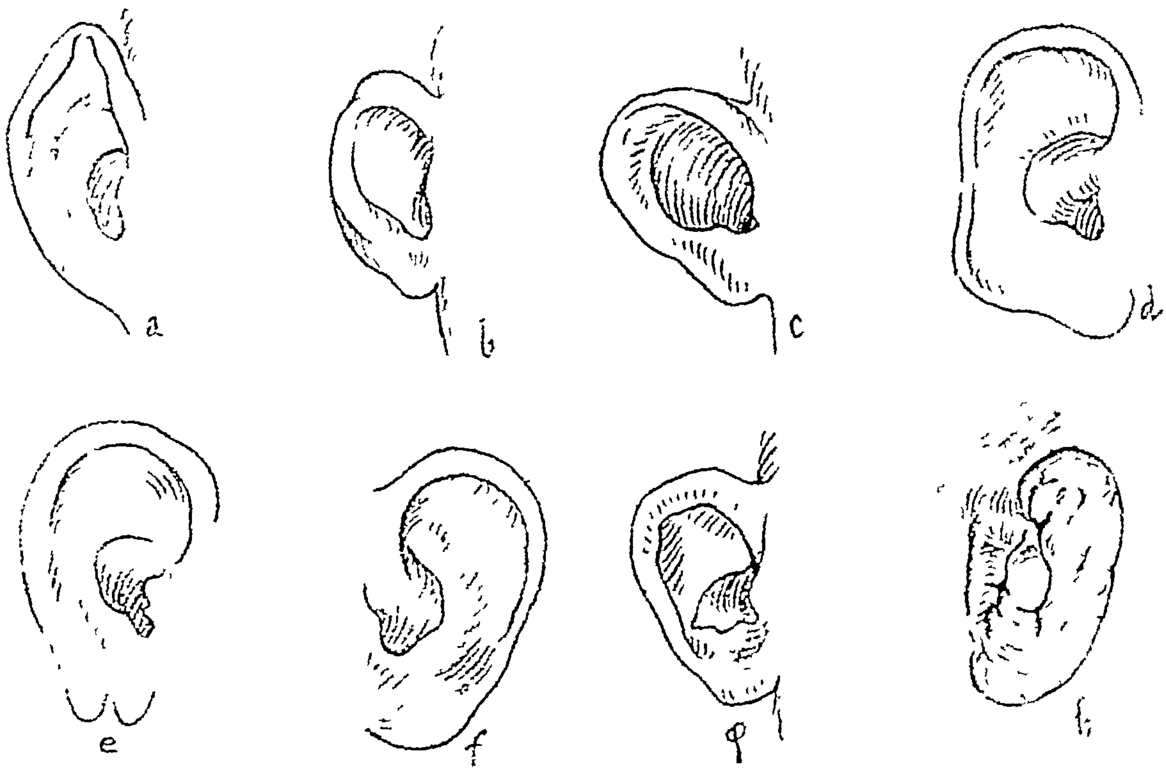


FIG 571 Common errors in shape of auricle

the posterior surface being left intact (35) (fig 572) When the perichondrial and the skin margins of the wound are approximated, the helix will tend to roll in and thus eliminate the deformity.

Pointed ears may be treated in a similar manner, or correction may be attained by a mere excision of the point, care being taken to leave enough skin to cover the margins

Shell Ears

For the restoration of the normal folds Eckstein (17) uses the following technic (figs 573-574). From the posterior aspect of the auricle an elliptic section of skin and perichondrium 2 cm long and 0 5 cm wide is excised on a line with the usual site of the anthelix A longitudinal incision is then made in the cartilage thus exposed, the anterior skin being left intact By pushing the edges of cartilage forward, a fold is formed

beneath the skin on the anterior surface. This fold is maintained in position either by suturing the adjacent perichondrial surfaces, or by passing a through-and through mattress-suture of silkworm-gut through the base of the fold on the anterior aspect

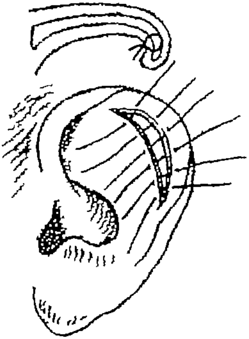


FIG. 572. Correction of flat triangular ear Crescentic section of anterior auricular skin and cartilage removed from flattened area. Insert, sectional view showing rolling in of helix when perichondrial and skin margins of wound are approximated (Joseph)

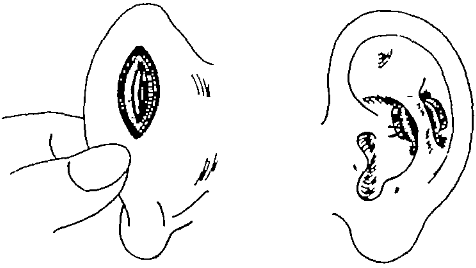
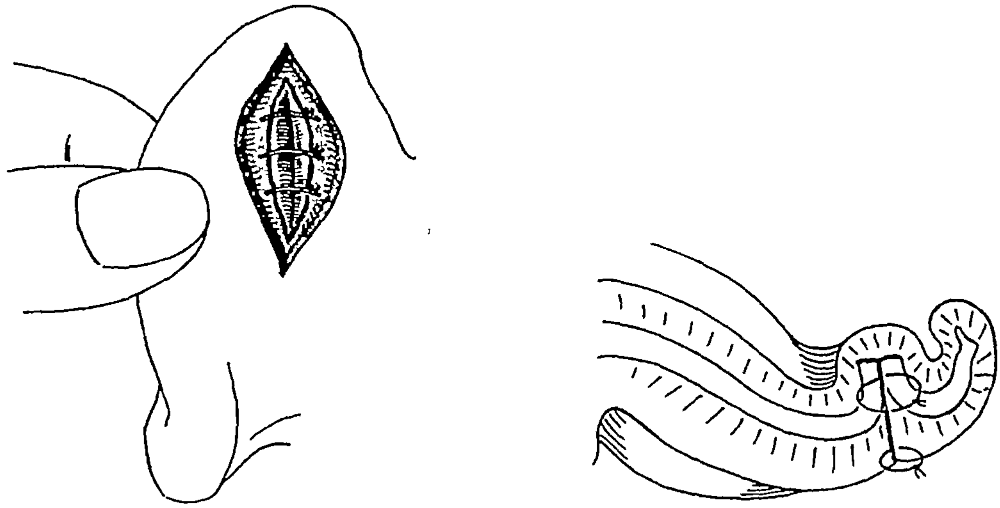


FIG. 573 Correction of shell ear by construction of anthelix. a, elliptic section of skin and perichondrium removed from posterior aspect of auricle. Cartilage incised longitudinally b edges pushed forward, to form fold on anterior auricular surface. Mattress-suture passed through base of fold and tied over pad of gauze, to immobilize cartilage. (Eckstein)

of the ear, and tying it over a pad of gauze as a protection to the skin. Finally, the posterior skin incision is closed. Kleinschmidt (37) proceeds in a similar manner but prolongs the cartilaginous incision for a distance sufficient to break the spring of the cartilage.

The writer operates as follows: A section composed of skin and perichondrium is removed from the posterior aspect of the ear along the site of the proposed anthelix, as in the Eckstein-Kleinschmidt (17, 37) operation, but the cartilage, instead of being divided, is shaved with a sharp knife, the base of the trough thus formed being left as



a b

FIG 574 Correction of shell ear by construction of anthelix *a*, elliptic section of skin and perichondrium removed from posterior surface of auricle Cartilage incised longitudinally Edges pushed forward, to form fold on anterior auricular surface and immobilized by sutures passed through perichondrium *b*, sectional view (Kirschner)

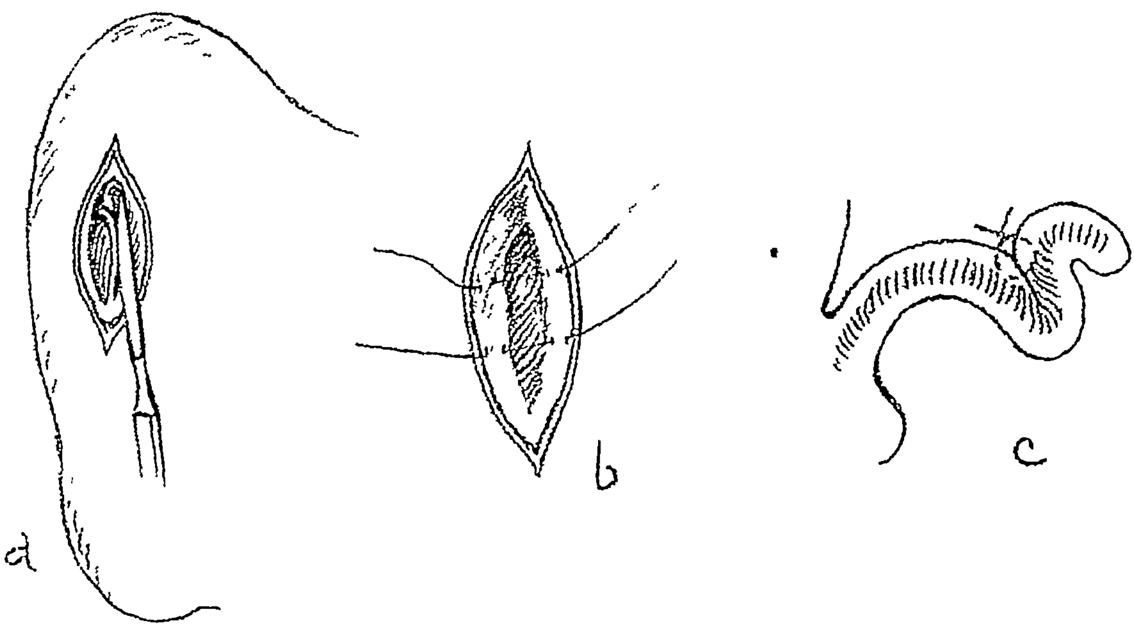


FIG 575 Correction of shell ear by construction of anthelix *a*, cartilage shaved, to form trough *b*, Lembert sutures passed through perichondrium, to cause eversion of thinned cartilage *c*, sectional view, showing effect when sutures are tied

thin as possible (fig 575) The margins of the perichondrium on either side of the trough are united with catgut sutures of the Lembert type, which when tied will cause the thinned cartilage to buckle anteriorly The posterior skin edges are then approximated and the usual dressing applied The operation is entirely satisfactory and creates a graceful anthelix of normal appearance

Davis and Kitlowski (13), after removing the required amount of cartilage and breaking the spring of that which remains, create a new anthelix by "turning forward the margins of the cartilage to form a supporting ridge. This is done by passing a catgut suture (No 0 or No 1, plain) through the perichondrium on one side beginning about 0.5 cm. from the cartilage margin and coming out close to the margin The needle is then carried across the defect and enters the perichondrium a similar distance from the margin and then out about 0.5 cm from the defect. This suture is of the Lembert type. Four or five of these sutures are placed and then all are drawn up at one time and are tied in order It will be found that the cartilage edges have been turned forward toward the anterior surface of the ear, replacing the unfolded portion of the antihelix, and that the ear immediately assumes a position which approximates normal. The skin is then closed with on-end mattress sutures of horsehair"

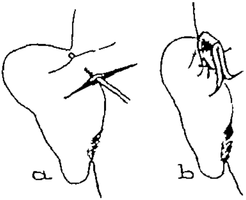


FIG. 576 Correction of lop ear *a* oblique double-pedicled skin flap outlined on posterior aspect of auricle and mastoid process. *b*, skin flap pinched up, drawing ear into proper position, and sutured After union takes place buckle of skin removed. (This operation is employed when the condition is due to lack of resiliency of the cartilage.)

Lop Ears

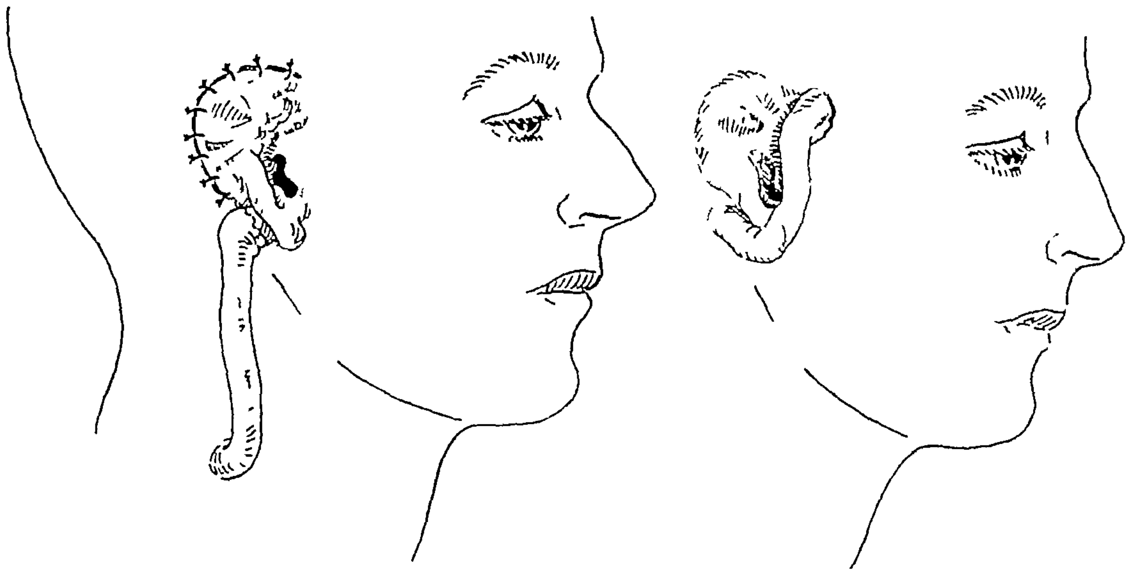
The management of lop ears will depend upon the underlying cause If the deformity is due to an absence of the natural folds, any one of the procedures described for the correction of shell ear will cause the auricle to assume its normal position If it is due to a lack of resiliency of the cartilage, 2 parallel incisions are made, extending obliquely downward from the mastoid process onto the posterior aspect of the auricle. The double-pedicled skin flap thus outlined is raised and pinched up until the ear is drawn into the proper position, whereupon it is sutured, raw surface to raw surface (fig 576) After healing has taken place, the buckle of skin on the back of the ear is excised (58) A band of fascia lata stretched between the auricle and the mastoid process will effect a similar result (40) (fig 561)

Auricular Deficiencies

It has been estimated that partial or complete absence of one or both ears occurs once in every 20 000 births (51), the condition usually being associated with an absence of the auditory canal. More commonly these deformities are acquired as a result of trauma, the removal of neoplasms, or degenerative conditions, such as syphilis and lupus.

Total Absence

The first surgeon to outline a definite technic for the restoration of an entire auricle was Szymanowski (59) (1870) in his "Handbook of Operative Surgery" His procedure consisted essentially in the raising of a large butterfly-shaped flap of skin from the



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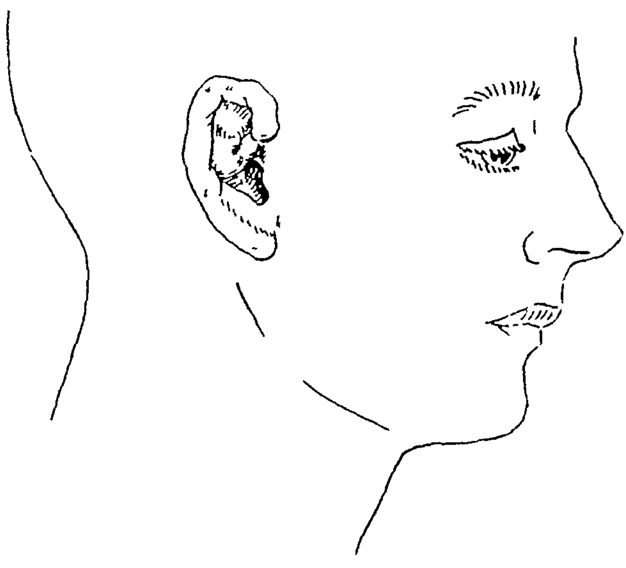


c

FIG 577 Pierce operation for reconstruction of ear following total loss *a*, shaped cartilage graft buried in pocket made between scalp and temporomandibular fascia Tubed flap raised from side of neck below defect After organization, skin-cartilage flap raised, and under surface skin-grafted on stent mold *b*, lower end of flap severed and attached to upper part of proposed helix *c*, skin-cartilage flap separated from head Stent removed, and balance of tubed flap fitted to outer margin of skin-cartilage flap

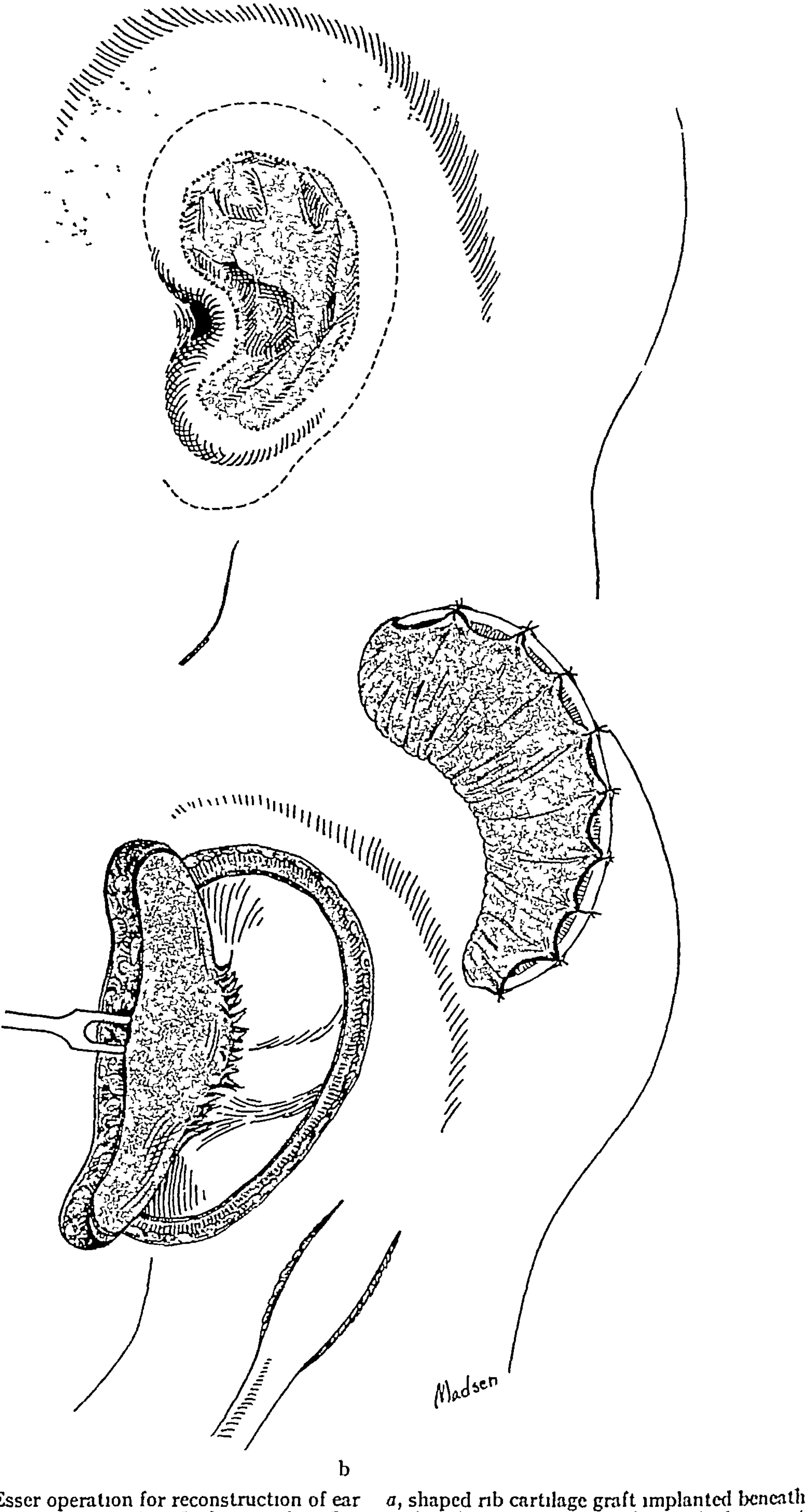
mastoid region and scalp The flap was folded at its narrowest point, raw surface to raw surface, and was sutured into a freshened area in front of the meatus Obviously, this operation is merely of historical interest While it is possible to raise a skin flap of this size, without support it is bound to contract into a shapeless mass with little semblance to the normal organ Furthermore, the posterior part of the newly formed

auricle would necessarily be composed of hair-bearing skin, while the secondary defect on the scalp would be left hairless.

As previously stated, the replacement of an entire ear is still without exception the most difficult task in the field of reconstructive surgery. Only in the past few years has the technic been improved sufficiently to justify the operation, and even with modern methods the results are at best qualified. Pierce's (51) operation probably offers the best solution of the problem. It can be performed under local anesthesia and requires hospitalization only for the removal of the rib cartilage. The steps are as follows (fig. 577).

(1) *Removal and Implantation of Cartilage.* A strip of cartilage 4 cm. wide and 6 cm. long is excised from the eighth or ninth rib (p. 184). After the removal of the perichondrium the graft is shaped to conform to that of the normal concha and inserted into a pocket between the scalp and the temporomandibular fascia through an incision lying 6 cm. above and behind the external acoustic meatus. At the same sitting a tubed flap 1 cm. in diameter and 16 cm. long is raised from the side of the neck just below the defect (fig. 577-a). (2) *Skin-Grafting of Under Surface of Cartilage Flap.* Four to 6 weeks later a semilunar incision is carried through the temporomandibular fascia along the line of the proposed anthelix and at a radius of 5 cm. from the upper border of the acoustic meatus. The skin-cartilage flap is raised, and a model of the underlying defect is made in stent, covered with a thin razor graft, and placed under the flap, the edges of which are then sutured back into place. (3) *Removal of Stent and Transplantation of Lower End of Pedicle.* Ten days later the suture line is opened and the stent removed, at which time the under surface of the flap and the scalp wound will be found epithelized. The lower pedicle of the previously constructed tubed flap is then cut and implanted into the site of the proposed lobule (fig. 577-b). (4) *Formation of Helix.* Three to 4 weeks later the remaining pedicle is severed, and the tube is opened and sutured along the revivified margin of the newly constructed ear to form the helix (fig. 577-c). (5) *Secondary Modeling.* Before a satisfactory result can be attained, minor secondary modeling operations will be required, together with additional implantations of cartilage.

Esser (24) operates in much the same manner (fig. 578). An arched incision is made in the skin over the site of the proposed auricle. The margins of the flap thus outlined are undermined as far as the external acoustic meatus. A properly shaped piece of rib cartilage is implanted beneath the flap, which is then sutured back in place. After the cartilage has become established in its new location, the skin-cartilage flap is raised from the underlying bone, and between its posterior surface and the side of the head a razor graft on a stent mold is inserted. In 10 days the stent is removed, leaving an epithelized surface on the back of the ear and on the side of the head. A tubed pedicle flap is raised from the neck and utilized for the construction of a helix after the manner of Pierce (51). Schmeiden (56) (1908) reconstructed an ear from skin of the breast. The process required 5 stages and extended over a period of 3½ months. The technic is briefly as follows: (1) An ear-shaped disk is removed from the costal cartilage and inserted under the skin of the breast. (2) Three weeks later the cartilage, together with the overlying breast skin, is raised in the form of a double pedicled tube flap. (3) After an interval of 17 days the pedicle of the flap is prolonged to the clavicle. (4) When vascularization has taken place, the lower end of the flap is severed and



b

Fig 578 Esser operation for reconstruction of ear *a*, shaped rib cartilage graft implanted beneath scalp at site of proposed auricle *b*, skin-cartilage flap raised, and posterior surface skin-grafted on stent mold Tubed pedicle flap raised on neck, to be utilized for construction of helix

sutured into a denuded area around the auditory canal to form the upper pole of the new ear (5) Four weeks later the remaining pedicle is cut and fitted into a pared area around the canal to form the lower pole of the auricle.

Gillies (26) cites a case wherein he reconstructed an ear by the use of maternal auricular cartilage. His procedure is as follows '*First Operation The Donor Ear* An incision is made parallel to the margin of the helix on its posterior aspect, and the skin peeled off the cartilage both on its posterior and anterior aspects. Care is taken not to break the cartilage on the one hand or perforate the skin on the other When the whole of the cartilaginous block has been thus isolated down to the level of the external auditory meatus, it is cut across, washed in saline, and kept in a wet saline cloth The skin incision is sutured and a mold of the natural ear hollows is constructed to support the skin during the healing process. A maternal deformity of a crumpled auricle except in its lower part is to be expected.

"*Second Operation The Recipient's Ear Stage One* A flap is designed with its base forward, but only the lower incision is made through which cartilage may be inserted. The skin is undermined very close to the dermis and all bleeding stopped The maternal cartilage is now inserted through the incision, and it should be noted that there should be enough skin freed to go into all the hollows present in the natural cartilage. To maintain the skin in this position small packs of consolidated gauze or sponge are cut to fill each hollow leaving the ridges in between. These are stuck down with benzo-mastich and when the dressing is complete the pressure on the surfaces of them ensures that the skin becomes adherent to each of the various hollows. *Stage Two* After a period of not less than three months the original incision is re-opened and the flap outlined by making posterior and superior cuts. Care is taken to see that at no time is the cartilage itself exposed nor in any case cut into If possible enough skin on the posterior-superior border should be included in this flap as to turn over the edge of the helix. By suitable undermining this cutaneo-cartilaginous flap can now be swung into the position of the normal upper three quarters of the ear In this position it looks exactly like the normal ear except for the lack of posterior covering of skin, and also for the lobule and lower part of the concha. It is attached in its new position usually to some portion of the rudimentary ear both above at the crus helicis and below at the conchal hollow " The raw area on the back of the newly formed ear and over the mastoid process is covered with a razor graft on a stent mold or with a tubed flap formed at the first operation.

Gillies (26) also suggests a plan which has not as yet been tested but which seems worthy of trial—i.e., "to attach a loose bag of skin by means of a pedicle flap into the position of the ear Then to graft in succession pieces of iliac bone, which would get thoroughly adherent to the mastoid, and to add to these until a sufficiently large block of bone has been grafted to enable the shape of a new ear to be carved out of this block of bone. The skin covering would be induced to take up its position in the hollows made by the carving "

Smith (57) constructed an entire ear on the arm and transferred it to the final site on a tubed flap

Padgett (43) describes a procedure for the reconstruction of a total auricle performed in 3 operative sittings. Each stage requires a week's stay in the hospital, and the intervals between operations are two months or longer After the last stage subse-

quent modeling operations to secure the final results are carried out in the Out Patient Department of the hospital or in the office

The steps of the operation are as follows (fig 579). "*First operation* . in the total reconstruction of a congenitally deformed auricle, as a rule, the rudimentary cartilaginous masses are removed and discarded. If the auricle is to be rebuilt because of a major congenital malformation, the next step may be the removal of some bone about and posterior to the position of a normal meatus so that a depression in the bone is made which will imitate the cavum or even a rudimentary meatus The skin flaps which remain after the rudimentary cartilage and bone have been removed are applied directly to the bone to form a lining for the newly formed cavum .

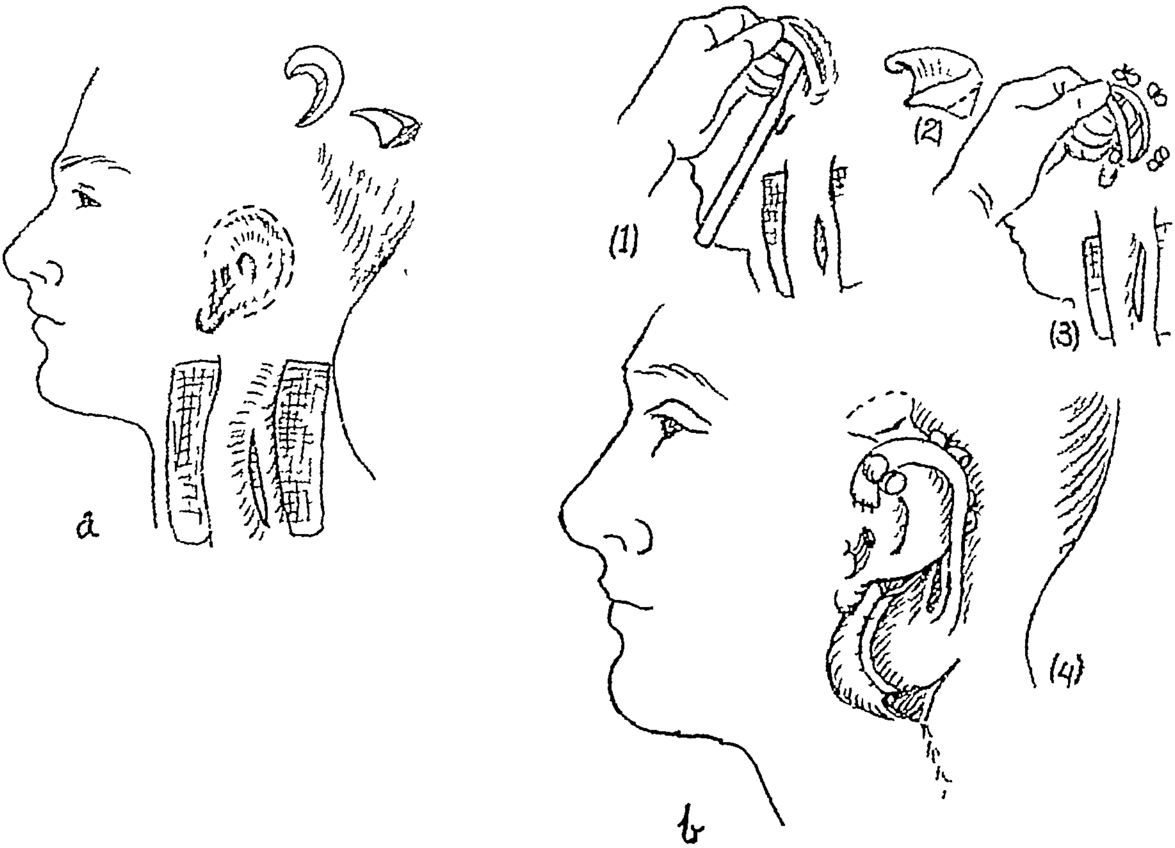


FIG 579. Padgett operation for reconstruction of total ear For details, see text

"Through either an oblique or a vertical incision the cartilages of the eighth or ninth ribs on the right side are exposed. A lead pattern is used as a guide as to the amount of cartilage which will be needed . A block of cartilage is removed . . hollowed out so that the shape of the cavum, the antihelix, and the helix is imitated Allowance is made for the thickness of the flap which will cover the cavum. . .

"Through a small incision posterior and above the ear after a fairly wide undermining of the soft tissues posterior to the meatus or the position of the meatus in a plane just superficial to the periosteum of the skull, the cartilaginous framework is inserted in a position judged to correspond to relationship as to height and anterior posterior direction to the opposite auricle The wound is closed by interrupted sutures without drainage and a pressure dressing consisting of wet gauze and a marine sponge is placed over it to prevent the formation of a hematoma about the cartilage.

"Along the lateral side of the neck with the base near the tip of the mastoid process a flap is raised and tubed. This flap will have to be adequate to cover the posterior part of the ear and to form a small tubed roll which will be used to imitate the helix. The flap is split at its lower end. The smaller flap should be a narrow piece of skin and subcutaneous tissue about 12 centimeters long and 1 centimeter wide Each end is left attached and in the middle a narrow attachment to the larger flap of about 1 centimeter is left uncut for a time. The temporary midway attachment helps to guarantee the blood supply Before the second operation both of these tubed flaps should be cross sectioned over the clavicular region and resutured back in place.

"*Second operation* An incision is outlined posterior to the cartilaginous mass previously buried. The anterior skin flap and the cartilaginous mass are turned forward after the cartilage is dissected free from the periosteum of the bone on which it had been laid previously All along the circumference of the posterior edge of the semicircular cartilaginous transplant is trimmed a wedge shaped piece of cartilage with the base of the wedge posterior

"The tubed flaps previously prepared on the neck are crosscut a second time at their distal ends. The distal end of the large tubed flap is unrolled. This flap is used to cover the posterior part of the new ear or, in other words, the posterior part of the cartilaginous framework. This flap is passed an inch or so above the auricle and attached to the scalp side above the ear This prevents the weight of the pedicle from pulling the ear out of position downward. The periosteal raw surface on the cranium is covered with a skin graft.

"The small tubed flap is not unrolled. It is used to attach at periodic intervals around the anterior upper and posterior edge of the ear The fact that it is only attached at intervals of about ½ centimeter keeps it rolled permanently and thereby the form of the helix is imitated

"For pressure and fixation a modeling composition form is molded over a split skin graft. This is held in place by sutures crossed above the stent at appropriate points. Anteriorly, they are passed through the ear and tied on some type of form such as a small piece of rubber tubing

"*Third operation.* The 2 flaps are crosscut near the new auricle and readjusted and sutured in place. What is left of the pedicle is unrolled, replaced, and sutured to the skin of the neck as the scar is excised.

"Finally if there is additional shaping of contour, it is done in the office under no anesthesia if an innervation has not yet developed or under local anesthesia if indicated."

Partial Loss

If the loss of auricular tissue is not extensive, the deformity can frequently be corrected if the pared margins of the defect are approximated and the ears made symmetrical by a reduction of the size of the relatively large fellow ear Where the loss is too great for such correction, other methods must be employed, and the choice will depend upon the size and location of the defect.

If the loss involves *the lateral margin of the ear* Ombrédanne's (42) procedure may be employed to advantage. The technic is as follows (fig 580) An appropriately shaped piece of costal cartilage is implanted subcutaneously on a line with the proposed helix. When the cartilage has become established in its new location—a process which

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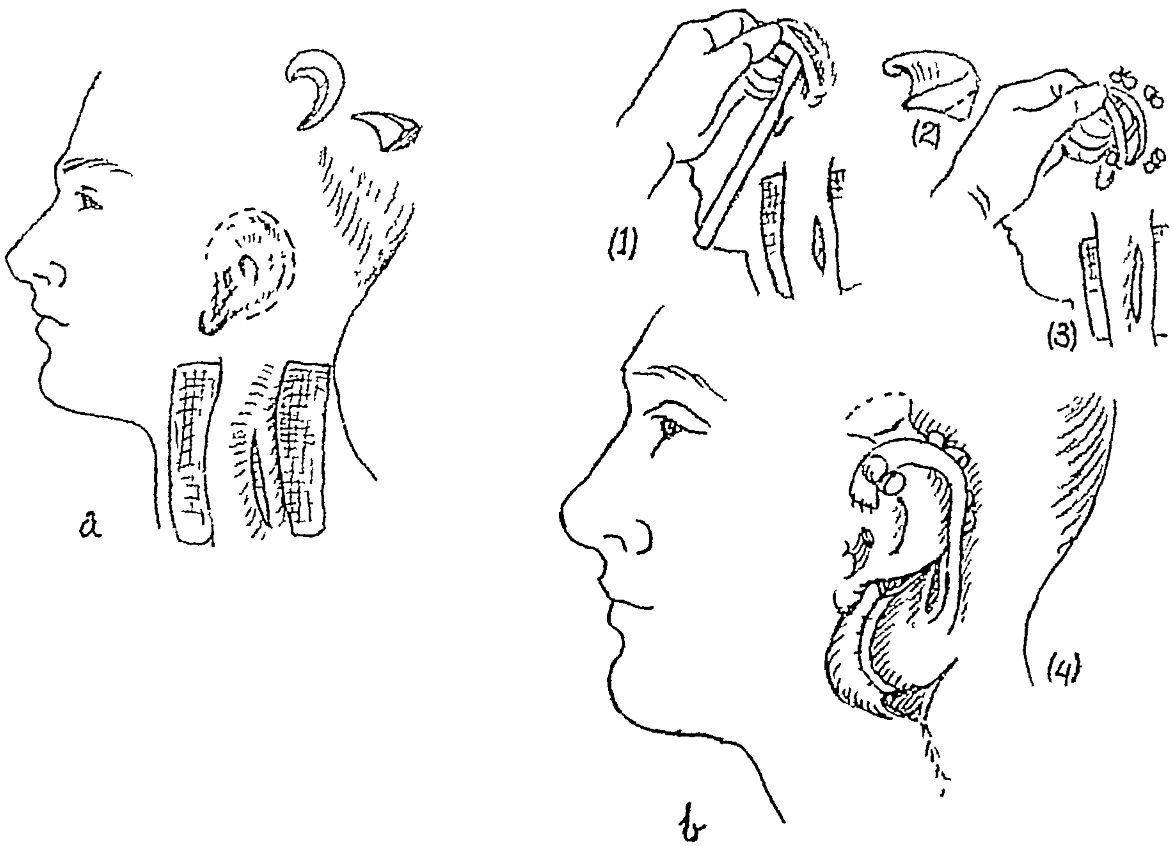

FIG 579 Padgett operation for reconstruction of total ear For details, see text

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"The small tubed flap is not unrolled. It is used to attach at periodic intervals around the anterior upper and posterior edge of the ear. The fact that it is only attached at intervals of about $\frac{3}{4}$ centimeter keeps it rolled permanently and thereby the form of the helix is imitated.

"For pressure and fixation a modeling composition form is molded over a split skin graft. This is held in place by sutures crossed above the stent at appropriate points. Anteriorly, they are passed through the ear and tied on some type of form such as a small piece of rubber tubing.

"*Third operation.* The 2 flaps are crosscut near the new auricle and readjusted and sutured in place. What is left of the pedicle is unrolled, replaced, and sutured to the skin of the neck as the scar is excised.

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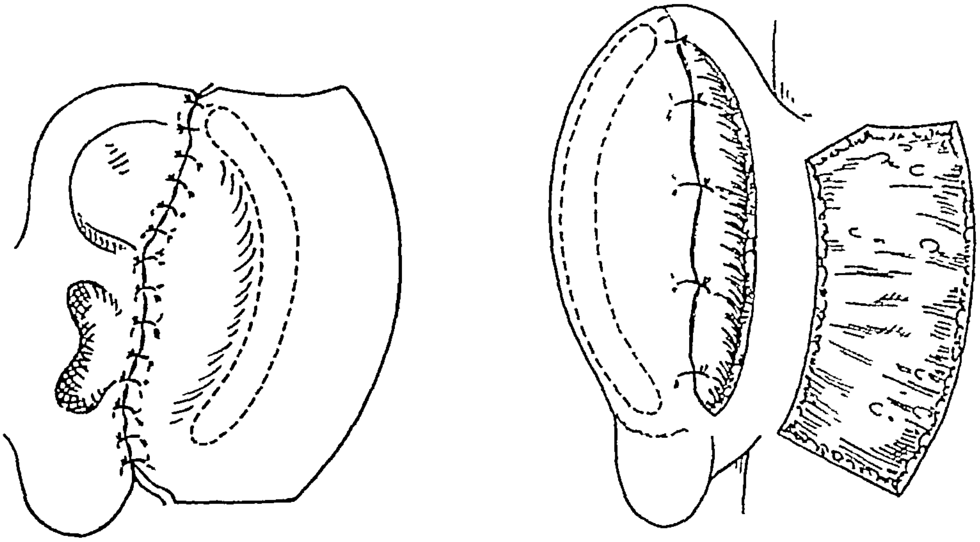
If the loss involves *the lateral margin of the ear*, Ombrédanne's (42) procedure may be employed to advantage. The technic is as follows (fig. 580). An appropriately shaped piece of costal cartilage is implanted subcutaneously on a line with the proposed helix. When the cartilage has become established in its new location—a process which

usually requires from 5 to 6 weeks—an incision is made in the skin contiguous to the defect, the skin margin is undermined for a few millimeters and is attached to the pared margin of the defect. Several months later the cartilage is raised in the form of a flap, enough skin being included to cover its posterior surface The posterior extremity of the flap is folded over, raw surface to raw surface, so that the implanted cartilage destined to form the helix is sandwiched in between the two layers of skin The raw area remaining is skin-grafted Subsequent minor modeling operations will be necessary to bring about the desired end results (fig 581)

In an endeavor to restore the *upper pole of the auricle* Lexer (39) removed a triangular section from the full thickness of the opposite ear, and, after elevating the skin on its posterior aspect to increase its surface area, implanted it into an appropriately prepared bed at the site of the proposed auricle (fig 582) Over the graft he applied



a b

FIG 580 Reconstruction following lateral loss of ear *a*, shaped cartilage graft inserted beneath site of proposed helix After vascularization, anterior margin of flap raised and sutured into pared margin of defect At another stage, flap raised over mastoid process, of such size as to permit its being turned over to supply lining *b*, mastoid flap raised and turned over, to sandwich in cartilage and cover posterior surface of ear Raw area remaining skin-grafted (Ombrédanne)

a pressure dressing which he left in place for 10 days At a later stage he raised a skin flap on the side of the head sufficiently large to permit of its being folded over to form a cover for the back of the auricle The secondary defect on the scalp he then skin-grafted The obvious objection to this procedure is that seldom can the opposite ear furnish a graft of such a size without a resultant secondary deformity; furthermore, should the graft fail to "take," an additional defect will have been created.

A more satisfactory plan for the replacement of such a loss is the following: An appropriately shaped piece of cartilage is introduced under the skin at the site of the defect When vascularization has taken place, a thin razor graft wrapped around a stent mold is inserted into a pocket made for the purpose beneath the cartilage transplant In 10 days the pocket is incised and the mold removed The lower border of the skin-cartilage flap is united to the pared upper margin of the remaining auricle The missing helix is replaced by means of a tubed flap from the neck, after the method of Pierce

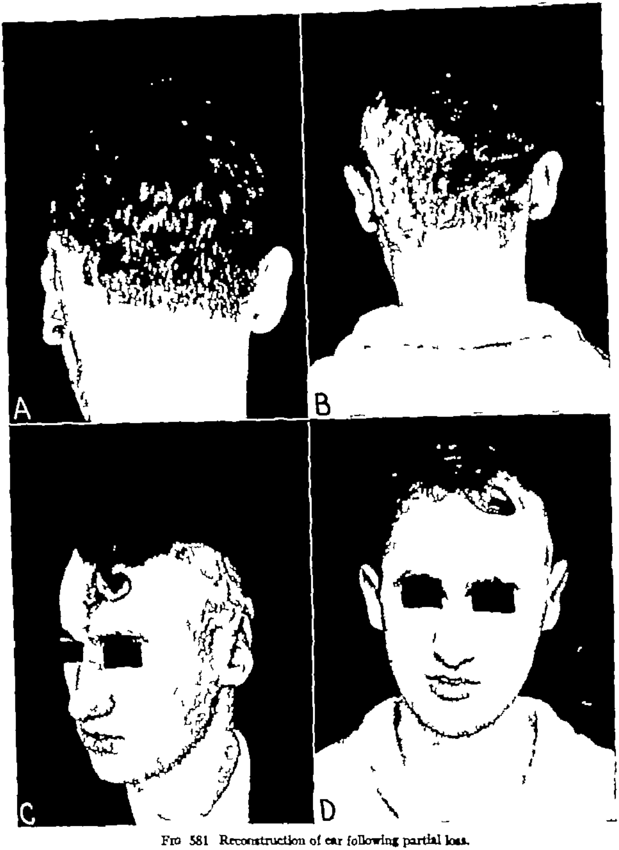


Fig 581 Reconstruction of ear following partial loss.

To reconstruct a missing lobule, Dieffenbach's (16) operation may be employed (fig 583) A skin flap of an appropriate size and shape is raised from the neck below the missing lobule and sutured to the pared margin of the defect. When vascularization

mold is removed, and the epithelized cavity which remains is cleansed and its edges trimmed As a precaution against subsequent contraction, the mold is replaced and worn for at least 3 or 4 months, being removed daily for purposes of cleansing

If a flap is to be used for lining the canal, it is secured preferably from the skin over the mastoid process Bouisson raises such a flap with its pedicle above. The lower end of the flap is tubed, raw surface out, and inserted into the newly formed meatus If the auricle is intact, as in the case of a cicatricial stenosis, the mastoid flap is made to pass through an incision in the concha before its introduction into the canal (fig 589)

MISCELLANEOUS AFFECTIONS OF AURICLE

Accessory Auricular Appendages

Small accessory auricular appendages composed of cartilage, fat, and skin are occasionally encountered in the vicinity of the tragus, helix, and cheek If the auricle is otherwise normal and these little protuberances create a deformity, they may be excised But if there is an associated deficiency of the auricle, as is frequently the case, they may be useful in its restoration, especially if they contain cartilage Under these circumstances they should be permitted to remain until the child becomes old enough for the auricular reconstruction.

Auricular Fistulae

Congenital fistulae of the ear are the result of an interference with the closure of the first branchial cleft They usually open in front of the auricle and either end blindly in a short canal, or open into the mouth, neck, or middle ear through a long canal They secrete a substance which irritates the skin, and should the opening be obliterated, the canal is apt to become cystic In order to effect a permanent eradication of these fistulae, it is necessary that the entire tract be destroyed; otherwise, they have a tendency to recur If the canal is short, it can be excised, but in the case of long canals excision of the fistulous tract may be difficult or even impossible In such instances recourse must be had to cauterization or x-ray therapy.

Acquired fistulae are usually consequent upon radical mastoid operations, especially after prolonged use of large drainage tubes Fortunately, with the improved technic in mastoid surgery, they are becoming less common These fistulae require treatment not only because of their unsightliness, but also because of their proneness to undergo infection Many operations have been devised for their obliteration, among which are the following:

(1) The walls of the tract are excised, and 1 or 2 tongue-shaped flaps, pedicled at the margin of the fistulous opening, are raised and turned into the canal, skin surface inward (fig 590) The remaining raw area is covered, when feasible, by undermining and approximating the wound margins When this is impossible without undue tension, the surface may be skin-grafted or covered with another contiguous flap from the vicinity

(2) Passow (48) makes a circular incision around the fistulous opening through which he elevates the skin and periosteum from the underlying bone as far as the margins of the defect The fringe of tissue thus raised is turned skin side in and gathered together by means of a purse-string suture of catgut The outer raw surface is covered by undermining and approximating the margins of the skin wound (fig 591)

(3) Ashley (3) describes a practical operation as follows (fig 592) Following the removal of all scar tissue about the fistulous tract an incision is made "parallel to, and

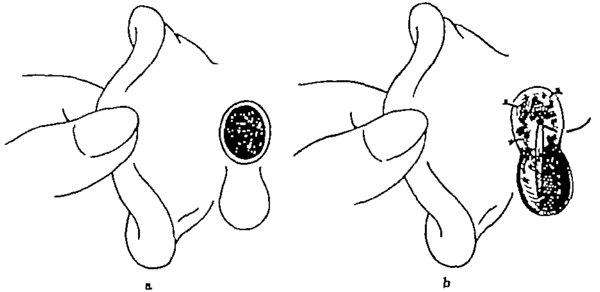


FIG 590 Closure of retro-auricular fistula. a, margins of fistulous opening excised. Tongue-shaped flap outlined, with its pedicle close to fistula. b flap turned over skin side in, to cover defect. Raw surface covered by undermining and approximating wound margins or by the use of another contiguous flap. (Mosetig-Moorhoff)

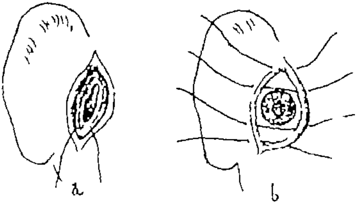


FIG 591. Closure of retro-auricular fistula. a, circular incision made around fistulous opening. Skin and periosteum separated from bone and turned, skin side in, over opening. Pursestring suture passed through rim of skin and periosteum. b pursestring suture tightened, to cover opening Skin wound closed by undermining and approximating margins (Passow)

FIG. 592 Closure of retro-auricular fistula. a, scar tissue excised. Flap raised adjacent and parallel to defect. b flap split into 2 layers Lower layer cut free at distal end and tucked into cavity c, skin flap shifted inward, and wound margins approximated For details see text. (Ashley)

one inch behind, the posterior margin of the wound, extending well above and below its upper and lower margins. " This incision is carried down to the bone The tissue

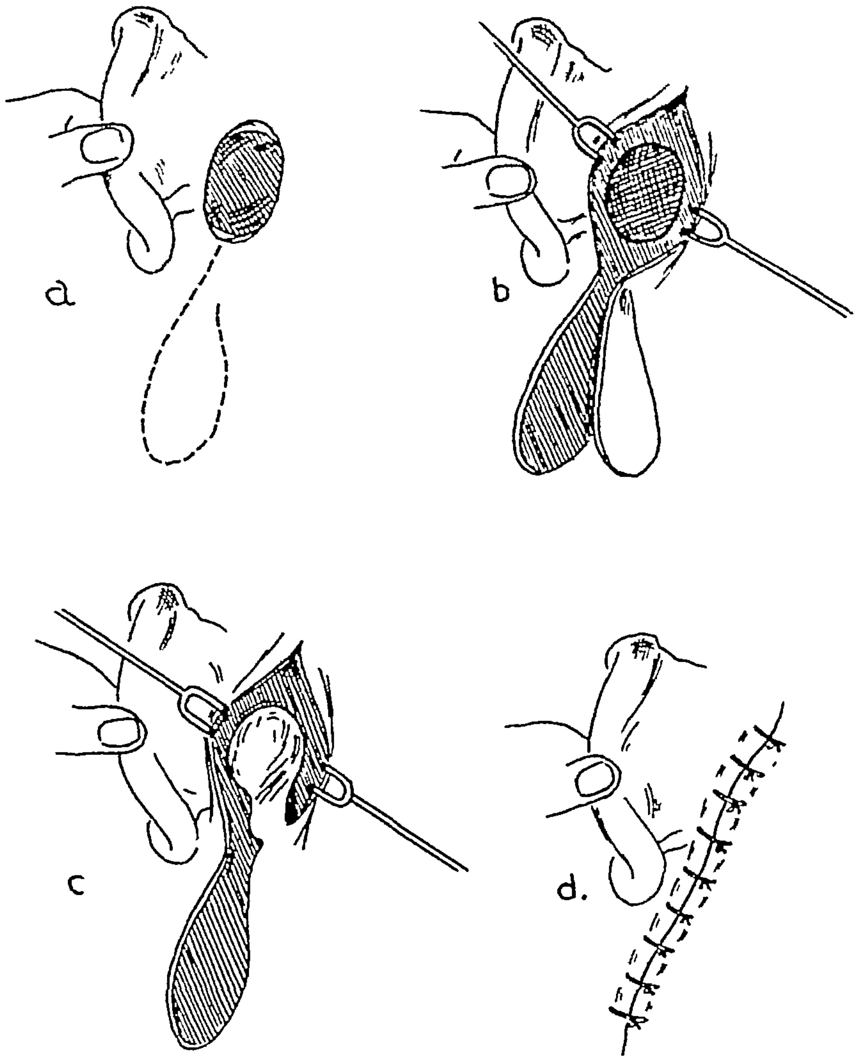


FIG 593 Closure of retro-auricular fistula *a*, flap outlined by dotted line *b*, flap raised and skin surface denuded *c*, flap tucked into cavity *d*, skin margins approximated (Eisner-Myers)

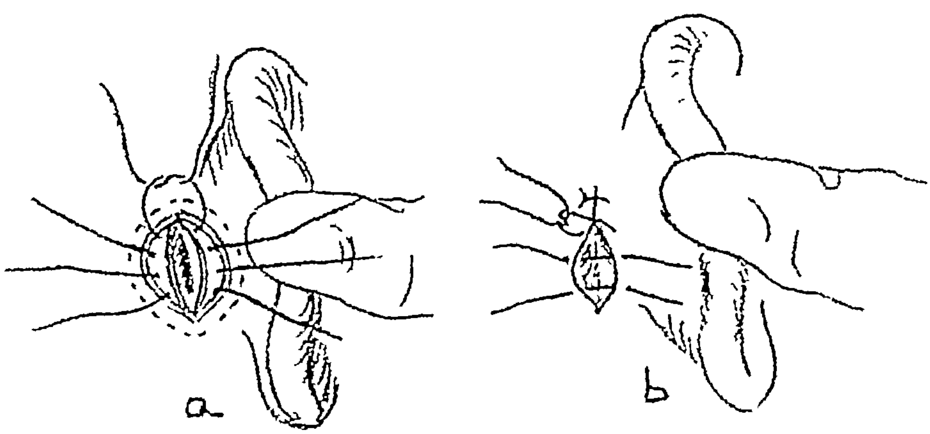


FIG 594 Closure of retro-auricular fistula *a*, two contiguous skin flaps raised along margin of defect, turned skin side in, and approximated *b*, skin edges undermined and united over raw surface (Troutmann)

between the defect and the incision "is carefully dissected up from the bone throughout its entire length, making a flap one inch wide, attached at the upper and lower ends, but freely movable mesially and laterally. The flap is then divided into two layers,

leaving as much thickness as possible in the lower layer The lower flap is then cut free from the upper flap at its lower border, thus forming two flaps, the upper consisting mostly of skin and subcutaneous tissue attached at both ends, and the lower composed of muscle, fascia, fat and periosteum, attached only at its upper end, its lower end being entirely mobile. The mastoid cavity is then freshened with a curet, and the muscle periosteum tongue flap' is tucked into the cavity with the periosteum next to the freshened bone The skin flap is then moved over and sutured to the undermined anterior skin margin of the wound. To cover the denuded area of the skull, a third incision parallel to and three-fourths of an inch behind the primary plastic incision, is made down to the periosteum by undermining the edges of this third incision the wound edges can be brought together and sutured without tension. All wounds are closed with mattress sutures of dermal or catgut. The routine mastoid dressing is applied and not disturbed for several days."

Other procedures which can be frequently employed to advantage are illustrated in Figures 593–594

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CHAPTER XIV

THE MAXILLOFACIAL REGION

For surgical purposes, this section will be made to include (1) the soft tissues of the cheek, and (2) the bones comprising the maxillofacial compound For convenience, the nasal and mandibular regions are discussed separately in Chapters XI and XVII

ANATOMIC CONSIDERATIONS

Soft Tissues The soft tissues of the cheek, with the exception of their central portion, are attached to the bones of the face From without inward they comprise 5 layers (1) The outermost layer, the *skin*, is continuous with that of the lips It contains numerous sebaceous and sweat glands and gives attachment to the flat muscles of the face which serve to move the skin on its osseous base and wrinkle it in expression (2) Immediately beneath the skin is the *superficial fascia*, composed of a layer of areolar tissue containing considerable fat, the expression muscles, the parotid duct, blood vessels; and branches of the facial and trigeminal nerves The fat gives roundness to the cheek It is most abundant in children and young women, and tends to atrophy in advanced age The expression muscles differ from muscles elsewhere in that they do not move bone on bone, and they have no distinct sheaths, their fibers lying scattered in the subcutaneous fat In consequence infection spreads readily into the subcutaneous tissues These muscles are dominated by two sphincters: one that purses the lips—the orbicularis oris, and one which closes the lids—the orbicularis oculi (figs 595-596) All other muscles of expression act as antagonists Between the zygoma and mandible the fascia is modified to encapsulate a pad of fat (sucking-pad) which separates the muscles of mastication from the buccal mucosa and serves to resist atmospheric pressure during the process of sucking (3) The third layer is composed of the *buccinator and masseter muscles* enclosed in the buccopharyngeal fascia, the latter being pierced by the parotid duct (4) Beneath these muscles lies the *submucosa,* containing many mucous glands opening on the surface (5) The innermost layer is the *mucous membrane* which lines the cheek and merges with that of the lips and gums, it shows the orifices of many mucous glands and of the parotid duct

Bones The *maxilla* is an irregularly shaped bone which forms the largest part of the facial skeleton, including part of the floor and outer wall of the nasal fossa, the roof of the mouth, and the floor of the orbits It is buttressed posteriorly by the pterygoid processes, laterally by the malar-zygomatic compound, and anteriorly by the frontal bone It is composed of a body, which houses the maxillary sinus, and four processes

The facial surface of the body looks forward and shows a permanent vertical ridge produced by the root of the canine tooth Just below the orbital margin is the infra-orbital foramen through which the infra-orbital nerve and artery emerge The medial border of the body presents the nasal notch, giving attachment to the soft parts of the

nose. The lower edge of the notch at its inner end is prolonged forward to form the anterior nasal spine, and above the notch is formed the outer wall of the nasal fossa. On its internal surface the bone presents a ridge the inferior turbinate crest, which articulates with the inferior turbinate bone The surface above and behind the crest is deficient, showing the large irregular opening into the antrum. The prominent posterior inferior angle of the body forms the tuberosity, which gives attachment to a few fibers of the internal pterygoid muscle and articulates along its rough internal border with the tuberosity of the palatal bone

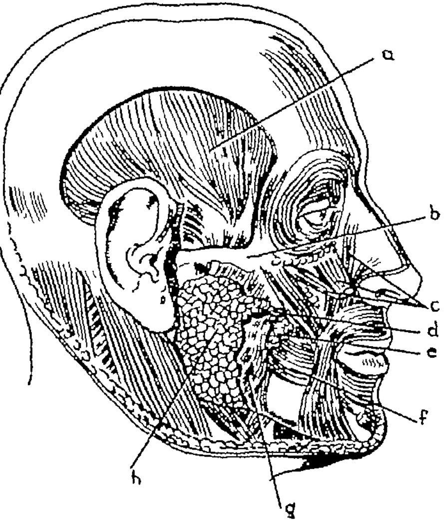


FIG 595 Muscles of face, dominated by two sphincters one that purses lips—orbicularis oris and other that closes eyelids—orbicularis oculi *a*, M temporalis. *b* os zygomaticum (malar bone) *c* M. quadratus labii superioris. *d* parotid duct (Stenson's) *e* pad of fat enclosed in fascia (sucking pad) *f* M. buccinator *g* M *masseter* *h* parotid gland.

The alveolar process is the thick arched lower border of the bone, which contains the alveoli or tooth-sockets corresponding in shape and number to the roots of the eight teeth which occupy them The palatine process, projecting horizontally inward from the junction of the body and the alveolar process, articulates with its fellow of the opposite side to form the anterior three-fourths of the hard palate. The upper surface of the latter forms the floor of the nose and the lower the roof of the mouth. Both surfaces are transversely concave, the upper is smooth, while the lower is rough and marked at its lateral margin with a groove for the accommodation of the vessels

and nerves passing forward from the posterior palatine canal The posterior border articulates with the horizontal plate of the palatal bone which completes the hard palate, while the medial border joins its fellow to form, superiorly, the vertical nasal crest, which is grooved to receive the vomer The part of the crest lying in front of the vomer abruptly becomes much higher and forms the support of the septal cartilage, ending in front in the anterior nasal spine The zygomatic process projects laterally and articulates with the zygomatic (malar) bone The frontal, or nasal, process is

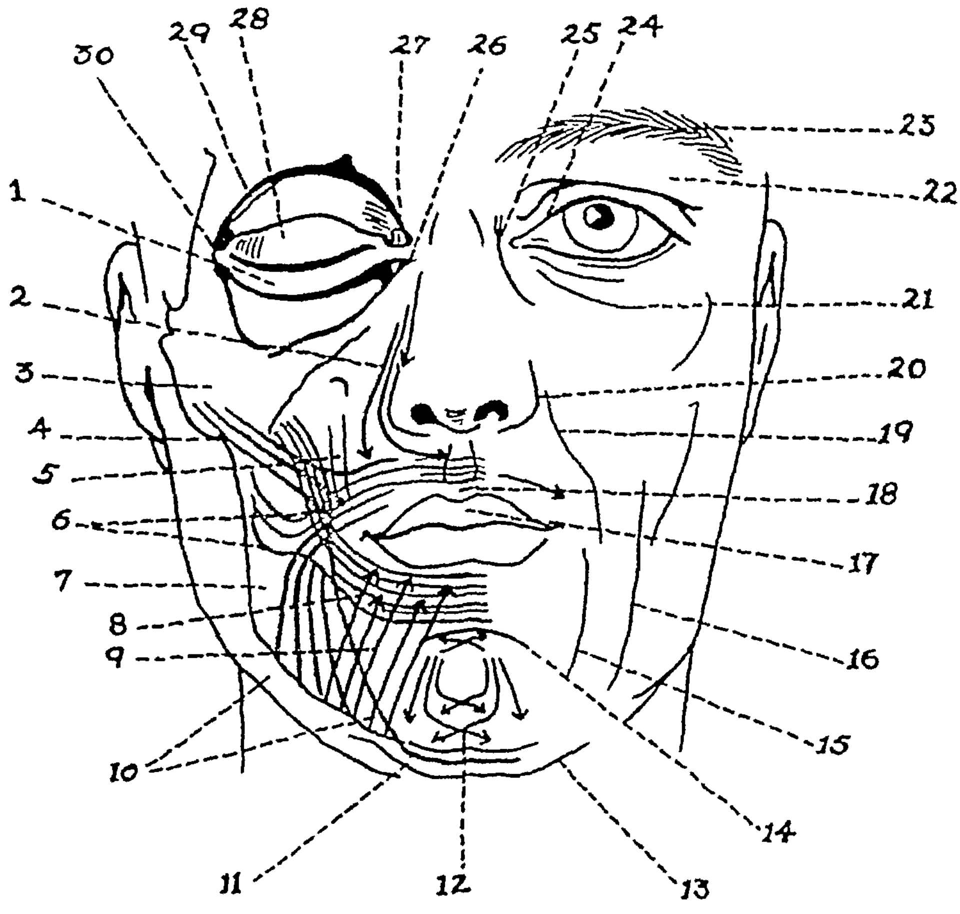


FIG 596 Diagram, showing antagonistic action of facial muscles to orbicularis oris. *1*, lower lid *2*, M quadratus labii superioris *3*, os zygomaticum *4*, M zygomaticus *5*, M caninus. *6*, M buccinator. *7*, mandible *8*, M orbicularis oris *9*, M quadratus labii inferioris *10*, M triangularis *11*, M transversus menti *12*, M mentalis *13*, mandible *14*, inferior labial groove *15*, buccinator groove *16*, masseteric groove *17*, upper lip *18*, superior labial tubercle *19*, nasolabial groove *20*, ala *21*, inferior palpebral groove *22*, upper lid *23*, eyebrow *24*, ciliary margin *25*, medial palpebral groove *26*, medial palpebral ligament *27*, lacrimal sac *28*, upper tarsal cartilage *29*, supra-orbital ridge *30*, lateral palpebral ligament (Braus)

a triangular plate of bone which projects upward and slightly inward to articulate with the nasal bone

The antrum, or maxillary sinus, is a pyramidal air chamber occupying the body of the bone and lined with mucous membrane The roof forms the floor of the orbit, and the medial wall the outer wall of the nasal cavity. Below, it is in relation with the palate, and laterally with the cheek Its thin walls correspond to the surfaces of the maxillary body, its apex to the zygomatic process, and its base to the nasal surface It opens into the middle meatus of the nose through one or occasionally two

apertures. Along its lower angle the roots of the first two molars often project into the cavity The antrum is sometimes partly and in rare instances completely, subdivided (79)

The maxilla, because of its strong buttresses resists fracture. But when a fracture does occur, the tremendous force required to produce it is likely to cause serious damage to important surrounding structures, such as the cranial vault the acoustic canal, the frontal and ethmoidal sinuses, and the orbital, nasal, and buccal cavities Fortunately, however, posttraumatic infection and osteomyelitis of the maxilla are uncommon, owing to the good blood supply and the superior facilities for drainage

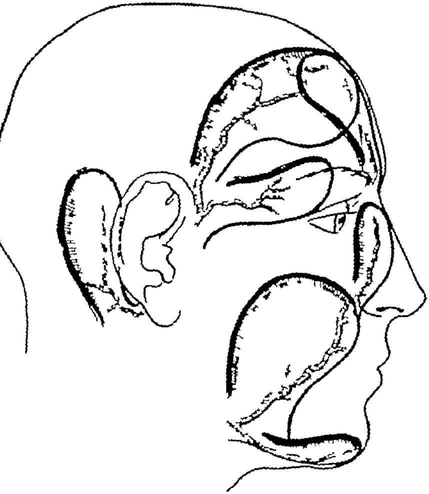


FIG. 597 Outline of flaps on head in relation to blood supply (See also Figure 113.)

The *malar zygomatic compound* is composed of the malar bone (os zygomaticum) and the zygomatic process of the temporal. The malar bone forms the prominence of the cheek and helps to separate the orbital from the temporal fossa. The body of the bone is strong and is rarely fractured but where it articulates with the frontal and maxillary bones and with the zygomatic process of the temporal, its supports are weak, and at these points fractures are common The outer surface of the malar is convex, the inner aspect is concave and faces the temporal fossa above and the zygomatic fossa below The bone shows three angles the upper one articulates with the external angular process of the frontal bone and the great wing of the sphenoid, the lateral one with the zygomatic process of the temporal bone and the remaining one with the

with its splintering glass, and are apt to suffer severe lacerations and contusions of the soft tissues of the face, as well as depressed fractures of the facial bones In overturn accidents the force is applied to the skull from the top of the car, and thus fractures of the vault are more commonly sustained than facial injuries

Diagnosis

In the event of severe facial damage, as in traumatisms of other parts of the body, the general condition of the patient must be investigated before an appraisal is made of the local wound (p 269) As soon as his condition permits, the wound is cleansed in the manner described on page 270 and examined The damage to the superficial soft parts can usually be determined by inspection, and the possibility of infection by a history of the circumstances surrounding the accident To estimate the damage sustained, the wound is separated and examined for muscle, mucous membrane, and bone involvement Injury to the facial nerve and the parotid gland and duct is best gauged by the symptoms occasioned (p 1015)

After the examination of the soft parts the facial bones are investigated for evidence of fracture If this is done promptly, it offers little difficulty, as the bones lie immediately beneath the skin and can be palpated throughout their entire extent Unfortunately, however, by the time the patient is seen the swelling, emphysema, and hematomata of the overlying soft parts have usually become so extensive as to mask the deformity and render palpation of the fracture difficult Significant symptoms of fractures in this region are malalinement of the teeth, epistaxis and emphysema caused by injury of the antral mucosa, subconjunctival hemorrhage from impingement of a fragment on the conjunctiva, pain on mastication and mechanical interference with mandibular movement resulting from the attachment of the masseter muscle to a fractured zygomatic arch, diplopia arising from loss of support to the eyeball, and anesthesia of the parts supplied by the infra-orbital nerve—notably numbness of the lower lid, side of the nose, upper lip, and maxillary teeth on the affected side—which may persist for months after the pressure has been relieved

Malar Fractures

While the malar bone is strong and in itself is rarely fractured, its supports at the frontosphenoidal, orbitomaxillary, and zygomatic attachments are relatively weak, and it is at these points that fractures are likely to occur Since the bone has no powerful muscular attachments, the direction of the force largely determines the nature of the fracture A blow from in front forces the bone backward into the antrum A blow from the side adds an element of rotation and tilting which may drive the fragment backward, downward, and inward, or backward, downward, and outward, telescoping it into the maxillary sinus

In cases of unilateral malar fracture inspection will reveal a peculiar facies characterized by a flatness of the traumatized cheek near the outer canthus and a swelling below Comparison with the unaffected side will assist in showing the asymmetry In rare instances the bone is displaced outward and gives rise to an exaggerated prominence over the cheek If the zygomatic process is fractured, it may have become separated from the malar bone and bent inward, interfering with the movement of the jaw by

impinging on the coronoid process of the mandible, or it may have been detached from the temporal bone and present an elevation in front of the ear If the fracture is in the region of the articulation of the malar with the frontal bone, it is evidenced by tenderness and irregularity over the upper outer quadrant of the orbital margin, if in the area of the maxillary articulation, there is an unevenness of the infra-orbital margin at its midpoint, and the inner extremity of the fragment usually projects upward into the lower conjunctival fornix where it can be palpated.

The displaced bone can frequently be located by intra-oral palpation. X ray examination is valuable, but the plates are not as clearcut as those taken of other parts of the body Exposures should be made in various positions to determine alterations in the relationship of the bones and the presence of foreign bodies Especially significant are irregularities along the lateral margins of the orbit.

Maxillary Fractures

Maxillary fractures may be unilateral or bilateral and are usually compound and impacted. Because of the anatomic structure of the bones, the line of fracture is more or less constant, usually taking a horizontal course Vertical fractures are rare since in this direction the more solid portions of the bone are encountered. Owing to the absence of strong muscular attachments, the displacement is principally in the direction of the continuation of the force (fig 599), although gravity plays a part.

When the blow is delivered from *in front* and to the upper central part of the face, there usually results a transverse uni- or bilateral fracture through the orbit, nasal fossa, pterygoid and zygomatic processes, the extent of the injury varying from a fissure to a complete separation of the facial bones from the base of the skull. The whole mass of bone may sag down and produce an elongation of the face, or the entire central section comprising the maxillary, nasal, and ethmoid bones may be driven backward, the upper teeth becoming alined behind the lower, so that the countenance assumes a "dish face" appearance. If the force is delivered *lower down* the line of fracture passes either through the antrum and nasal fossa or through the alveolus and palate, the resultant damage ranging in severity from a splintering of an alveolus to an impaction or complete separation of the entire alveolar palatal compound. The palate may be fractured horizontally or obliquely, the fragments either buckling to narrow the dental arch or separating to widen it. If the fracturing force is directed from *above*, the maxillofacial compound will be driven downward and backward toward the pharynx, and if from *below*, it will be carried upward toward the base of the skull if from the *side* the brunt of the blow will be received by the malar zygomatic compound which will be impacted into the antrum, the line of fracture extending radially to the maxilla, the infra-orbital ridge, and the alveolar process.

Generally speaking, if the patient is seen promptly, before swelling and emphysema develop to obscure the physical findings, maxillary fractures can be easily diagnosed from a history of the injury complaints of pain on mastication malocclusion of the teeth, and hemorrhage from the conjunctiva, nose, and mouth. But in the presence of extensive soft tissue damage or cerebral injury the condition may escape notice and be discovered only when the patient finds the malocclusion of the teeth interfering with mastication Simultaneous palpation of the orbital borders, zygomatic arches, nasal and maxillary bones and the two sides of the palate will disclose asymmetry and

reveal the extent of the fracture Localized tenderness referred to a constant point, especially when aggravated by lateral compression of the two sides of the face, is particularly significant. In the case of non-impacted fractures crepitus may be elicited by a gentle manipulation of the upper jaw with the fingers of the right hand while the temporal region is immobilized with the fingers of the left Injury to the infra-orbital nerve is evidenced by a lack of sensation over its area of distribution

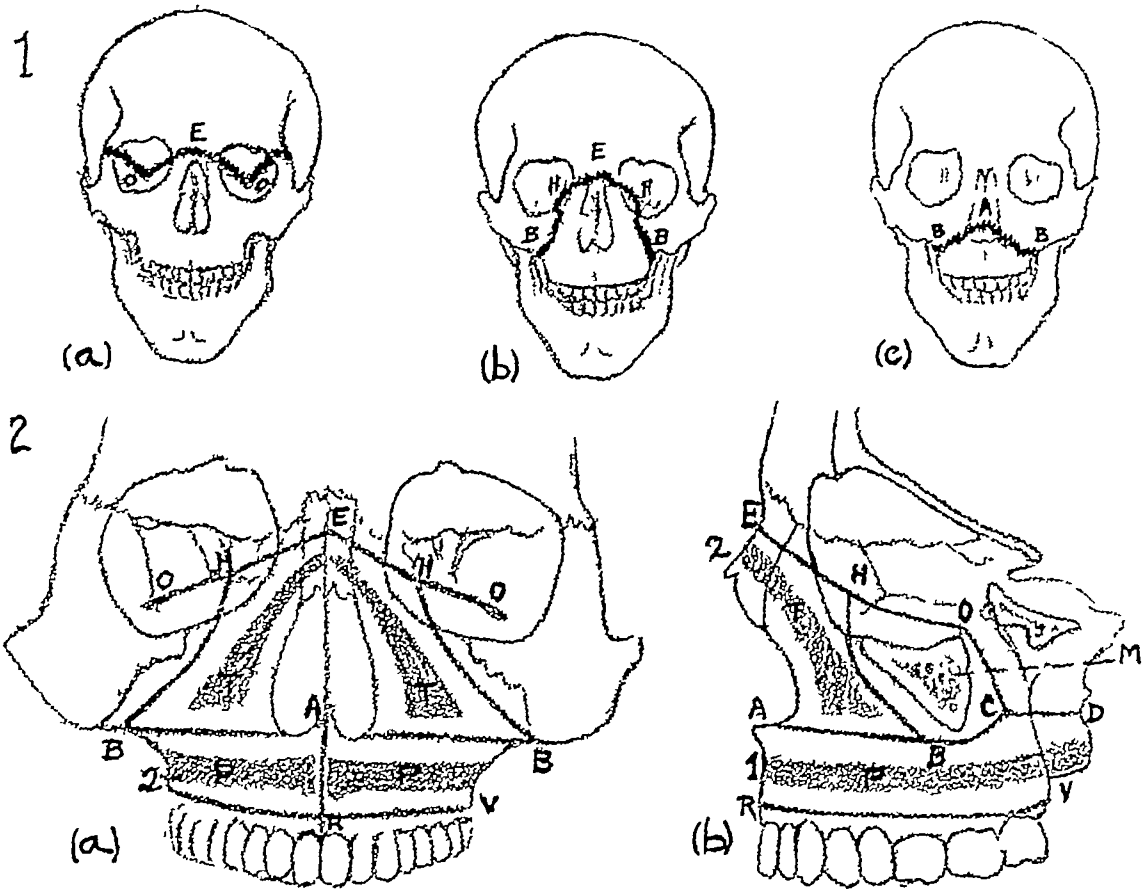


Fig 599 Sites of predilection for maxillary fractures *1a*, frontal force applied to upper part of face causes fracture line to run through orbit, with separation of facial bones from base of skull and elongation of face *b*, force applied to central part of face causes fracture line to pass through orbit, nasal fossa, pterygoid, and zygomatic processes, central section, consisting of maxillary, nasal, and ethmoid bones, driven backward *c*, frontal force applied to lower part of face causes fracture line to pass through antrum and nasal fossa, with separation of alveolar and palatal processes (LeFort) *2*, schematic representation of maxillary fractures *a*, frontal view *b*, lateral view *A–B–C–D*, through pyriform process, canine fossa, zygoma, pterygopalatine fossa, and pterygoid process of sphenoid *E–H–B*, through nasal bones, frontal process of maxilla, lacrimal bone, orbit, and malar process of maxilla. *E–H–O–C*, through nasal bone, orbit, frontal process of malar, and zygomatic arch (Piperno)

X-ray examination clearly reveals the site and extent of the fracture and the involvement of the tooth roots A fracture of the alveolar process will be shown up most effectively if a dental film is used, fractures extending into the orbit are best disclosed by a postero-anterior view, and backward displacements by a coronomental view

General Treatment

As in the case of injuries elsewhere in the body, the general treatment is directed first toward the preservation of life A certain amount of shock exists as a concomitant of all severe maxillofacial injuries, and until this condition has been relieved, no at-

tempt should be made to examine the wound, remove foreign bodies, suture the soft parts, or set fractured bones Under such circumstances the wound is covered with a sterile dressing If the shock is slight, the patient may be safely transported to a hospital, but if severe he is placed in the nearest available bed, kept warm, and subjected to as little disturbance as possible. The only indications for interference at this time are for the control of hemorrhage which is apt to be profuse because of the rich blood supply to the cheek, and for the relief of respiratory obstruction Ordinarily, bleeding can be checked by pressure unless the transverse facial or branches of the external maxillary artery have been injured In the latter event the severed vessel is grasped with a sterile hemostat and the wound covered with a sterile dressing until the parts can be satisfactorily cleansed, at which time the vessel is ligated and the hemostat removed. Occasionally, hemorrhage is so severe as to demand ligation of the external carotid artery Interference with respiration may be the result of a swelling of the nasal or pharyngeal mucous membrane. In the former case a drop of adrenalin chlorid instilled into the nasal fossa will reduce the swelling sufficiently to permit of free breathing, in the latter a large curved metal airway or rubber tube introduced into the oropharynx will serve to relieve the respiratory difficulty When the history reveals soil contamination, tetanus antitoxin and antigas bacillus serum should be administered after the skin has been tested for sensitization (p 268)

Definitive Treatment

The definitive treatment is directed toward (1) *care of the soft parts* (2) *care of the hard parts*, and (3) *management of residual deformities*

Management of Soft Parts

Cleansing and Débridement. As soon as the patient's condition permits, the sterile dressing originally placed over the wound is removed, and the surrounding skin and the wound itself are thoroughly cleansed (p 271) All foreign bodies, such as blood clots, pieces of glass and stone, are removed. Because of the exposed position of the part, special care must be directed to the removal of ground in dirt and roadway tar If superficial it is scrubbed off with a stiff brush, if deeply embedded, each particle is painstakingly picked out with a fine forceps or curet, or excised with a cataract knife. Failure to remove these bodies not only increases the possibility of infection, but also results in unsightly tattoo marks, which, when healing has once taken place can be removed only with difficulty In the case of large foreign bodies which are deeply lodged no rule as to their removal can be set down Each case must be governed by the individual circumstance.

The malar tissues, because of their abundant vascularity, have great reparative power and for this reason débridement in this region should be carried out with great parsimony In the case of incised wounds observed soon after their infliction, and in circumstances where no infection is anticipated, excision of the edges is unnecessary In lacerated wounds the ragged margins are trimmed sparingly, so that smooth, even surfaces may be provided for approximation, since irregular borders, even though they heal by first intention, leave a more noticeable scar But if such excision would entail too great a sacrifice of tissue, the wound had best be drained and allowed to heal by

granulation, the resultant scar being removed at a subsequent operation By so doing, tissue will be preserved and the ultimate cicatrix minimized Irregular tags of skin and mucous membrane, if of doubtful vitality, are excised (provided their excision does not interfere with easy closure of the wound), otherwise, they are preserved, however slenderly attached They may either be tacked down in their normal positions with a few subcutaneous sutures, or they may be supported by two strips of adhesive tape furnished with dressmaker hooks placed on each side of the wound and held together by means of elastic bands (fig 157) If left loose, these scraps may die or become so distorted as to be rendered useless for future repair. Even should some of this tissue be subsequently lost, there will be a greater saving than if all of it had been excised An attempt to reposition contused fragments of skin by recourse to a primary suture should be avoided, as such a procedure is likely to bring about necrosis and suppuration in the already devitalized tissue Completely severed portions of skin should be cleansed, freed of subcutaneous fat, and replaced in the hope that they will "take" as full thickness skin grafts

Trapdoor wounds require special attention, particularly if the edges are beveled, since in the process of healing the contraction of the scar on its narrow base produces a buckling of the flap which is difficult to correct at a later operation If the tissues are at all viable, the flap should be sutured back into its original position by means of a few fine white silk sutures, one bite being taken in the deep surface of the wound and the other in the under surface of the flap at a point beyond the thin margin, so that when the sutures are tied, the thin edge of the flap will overlap the defect (fig 156) The thin edge is then excised and the margins of the wound approximated by interrupted on-end mattress-sutures of fine silk If, however, the blood supply of the flap is doubtful, the flap is merely tacked down with a few deep sutures and a strand or two of catgut introduced for drainage In either case a pressure dressing is applied to hold the flap in intimate contact with its bed

Bone fragments still attached by periosteum should be replaced, since the bones of the face are well nourished and these fragments are likely to reunite Even when completely detached, it is better to replace them and risk sequestration, rather than remove the bony support with its resultant deformity

If the loss of tissue is so extensive that approximation of the margins is impossible without tension or distortion, new tissue must be supplied in the form of a graft or flap Should conditions permit, resurfacing is carried out at once, but if repair must be delayed (p 117), the parts surrounding the loss should be tacked down, otherwise, they are likely to heal in distorted relations and demand "untangling" before a satisfactory reconstruction can be accomplished In the case of full thickness losses wherein repair cannot be carried out immediately, the skin and mucous membrane are united over the raw margins of the wound, as a precaution against infection, and to forestall adhesions and prevent excessive contraction, the parts are held in their normal positions by means of a removable prosthesis attached to the teeth

Closure of Wound. The decision to close the wound by primary, delayed primary, or secondary suture is determined by the same principles that govern the treatment of wounds in general, and for the discussion the reader is referred to Chapter III Briefly, recent superficial clean wounds in which the loss of tissue is not considerable may be sutured without drainage But in the case of clean wounds which are deep, com-

municate with a fracture, or open into the buccal cavity, drainage must accompany suturing In infected wounds no attempt is made at closure the raw surface is allowed to granulate, and the resultant scar is removed at a later operation

Upon the accuracy with which the subcutaneous structures and the skin are united will depend to a large extent the nature of the residuary scar The subcutaneous tissues are built up by buried sutures of catgut or fine white silk. In the suturing of facial wounds it is particularly important to approximate severed muscles, since they lie so closely attached to the skin in this location that failure to unite them will result in a broad scar If a large trunk of the facial nerve has been severed, an attempt should be made to unite the segments by an end to-end anastomosis (p 1018), the threadlike character of the finer branches of the nerve, however, preclude the possibility of such repair If the parotid duct has been severed and the cut ends are readily accessible, they are united over a probe with fine catgut, all the layers being incorporated in the suture with the exception of the mucosa. If this cannot be accomplished without tension, an attempt should be made to carry the proximal end of the duct into the buccal mucosa to permit of the discharge of saliva into the mouth. In case this procedure is impracticable, no further efforts need be directed to the repair of the duct, since in the majority of cases no harm results. Should a salivary fistula develop, it is treated at a later date in the manner described in Chapter XVIII.

For skin suturing fine half-curved atraumatic needles are employed. The most suitable suture materials are ophthalmic silkworm-gut, horsehair, or fine waxed black Deknatel silk. For the closure of *linear wounds* a subcuticular suture is the one of choice, as it can be left in place for a longer period, is more easily removed, and produces no stitch marks. The needle is inserted into the skin 1.5 cm. below the lower angle of the defect and is brought out at the extremity of the wound itself It is then carried from side to side, picking up the corium at points 0.3 cm. apart along the entire course of the wound, and is made to emerge through the skin at a point 1.5 cm. beyond the upper angle of the lesion The wound margins are then drawn into apposition by the exertion of traction on the suture ends which are left long (fig 41) In the case of *long wounds* the suture is brought to the surface every 2.5 cm , to facilitate its removal. When the borders must be approximated under a certain amount of tension, two such sutures, one above the other, may be employed to advantage (221)

In *irregular wounds* interrupted sutures placed 3 mm. apart and 3 mm. from the edge are preferable (fig 35) Gillies' (87) description of the technic of introducing these sutures can hardly be improved upon "The hand using the needle-holder with needle should be pronated to its full extent so that the direction of the needle in its passage through the skin is away from the margin. The use of forceps grasping the whole skin edge should be avoided as far as possible. On bringing the needle out through the opposite side the eversion of the edge is accomplished in a different manner The needle point takes up a considerable quantity of subcutaneous tissue and the skin is then rolled backwards so that the point of emergence of the needle again comes close to the wound edge This rolling backwards can be done either with the finger or by using the forceps as a pressure point." The proper tension to be exerted on the wound margins can be more easily gauged if all sutures are passed before the knots are tied.

Dressing and After-Care. Unless a pressure dressing is indicated for the control of oozing, heavy dressings should be avoided, as they are likely to cause maceration of

the tissues Small wounds and those without secretions may be painted with a coat of Whitehead's varnish or covered with a strip of silver-foil over which is placed a layer of gauze held in place with mastisol Support is furnished by strips of sterile elastoplast crossing the suture line at right angles For large wounds a light pressure dressing is employed to prevent the accumulation of serum and diminish the amount of scar contraction A single layer of xeroform gauze is laid directly over the wound, above this are placed 1 or 2 layers of dry gauze, which in turn are covered with a moistened marine sponge, the whole being held snugly in place by means of a roller bandage An ice bag is applied over the part for 24 hours to reduce the swelling

When interrupted sutures have been used, half of them are removed in 48 hours and the balance in 72 hours Cutting the stitches one day and removing them the next will result in less scarring. Subcuticular sutures can safely be left in place for from 5

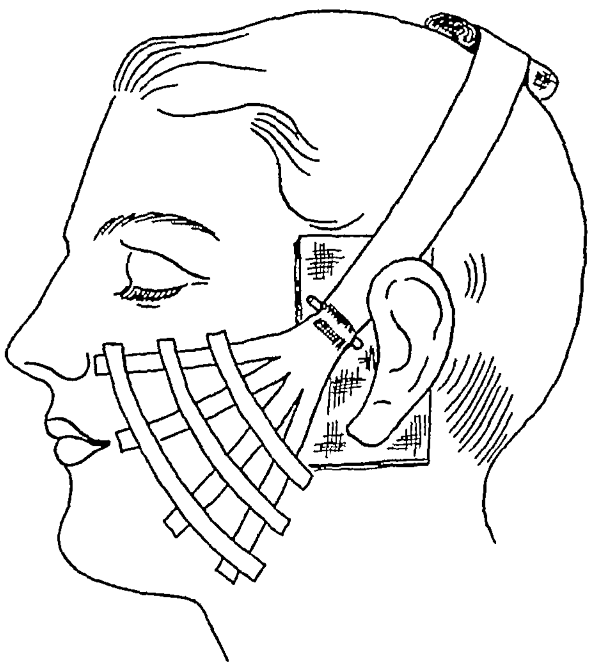


FIG 600 Reinforcement of suture line by strips of adhesive tape, to hold wound margins in apposition

to 8 days When all sutures have been removed, the line of union should be reinforced for 10 days with strips of adhesive tape placed at right angles (fig 600) or strips of gauze secured in place with mastisol To minimize cicatrization, suitable doses of x-ray or radium are applied to the fresh scar (p 1372) Any subsequent irregularities may be smoothed down with trichloracetic acid

Management of Maxillary Fractures

As has been said before, a high percentage of maxillary fractures are complicated with injuries to the base of the skull, orbit, maxillary sinus, and nasal fossa If there is evidence of cerebral damage (p 524), no attempt should be made to reduce the fracture for a week or 10 days, since the manipulation may open up avenues of infection in tissues already devitalized by trauma During this time the maxilla should be immobilized and all treatment centered on the brain injury (p 537) An excellent

emergency bandage recently described by Bichlmayr (22) is one consisting of a cylinder of wood wrapped in gauze, placed between the teeth, and held in place by a head bandage so applied that the wooden cylinder presses the downward displaced jaw upward (fig 601) The facial orifices are cleansed at frequent intervals as a precaution against infection.

Reduction and Immobilization. Reduction and immobilization of the fracture should be carried out as soon as the patient's condition permits. As in the case of fractures elsewhere, prompt reduction minimizes pain, allows *union in the corrected position*, and lessens the danger of infection. If reduction is delayed until the bones have undergone ossification in a faulty relationship, there will result malocclusion of

FIG. 601 Emergency bandage for immobilization of maxilla. Cylinder of wood wrapped in gauze placed beneath upper teeth, and held in place by bandage so applied that cylinder presses jaw upward. (Bichlmayr)

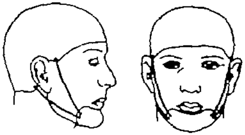


FIG 602. Immobilization of maxillary fracture unassociated with displacement. Dental arches wired in normal occlusion. Supplementary support obtained from elastic bands stretched between skullcap and strap beneath chin.

the teeth and a permanent deformity which, unlike mandibular fractures, cannot be corrected by a subsequent osteotomy

In *fractures with no displacement* all that is necessary is immobilization of the jaws The basic principle underlying this procedure is the same as that for mandibular fractures—i e. the fixation of the dental arches in normal occlusion. Since the use of the mandible as a sole point of anchorage before some degree of consolidation has taken place is not advisable because of its movability, some supplementary support must be obtained from the cranium Immobilization may be accomplished in one of two ways (1) By intermaxillary wiring of the jaws (p 1208), supplemented by two strong elastic bands stretched between a skullcap and a strap beneath the chin, in such a

manner that the body of the mandible is lifted upward (fig 602). (2) By fastening to the upper teeth an intra-oral splint and attaching it to some sort of headgear The splint may be in the form of (a) a Kingsley splint (159), (b) a heavy arched bar of silver wire attached to the outer surface of the maxillary teeth by several ties of fine wire, (c) a metal impression tray (113) secured to the teeth by softened stent and several wire ligatures, or (d) metal cap-splints (If the jaw is edentulous, the patient's dental plate may be used for the purpose) These splints are all equipped with heavy metal side-arms which emerge from the corners of the mouth and curve back over the cheeks In the interests of comfort, the headgear should be as light as is consistent with stability. It may be made in the nature of a plaster of Paris head-cap (p 1221) or a leather band, both being provided with hooks or wires The side-arms of the intra-oral splints are fixed to the hooks or wires of the headgear by means of elastic bands (fig 603)

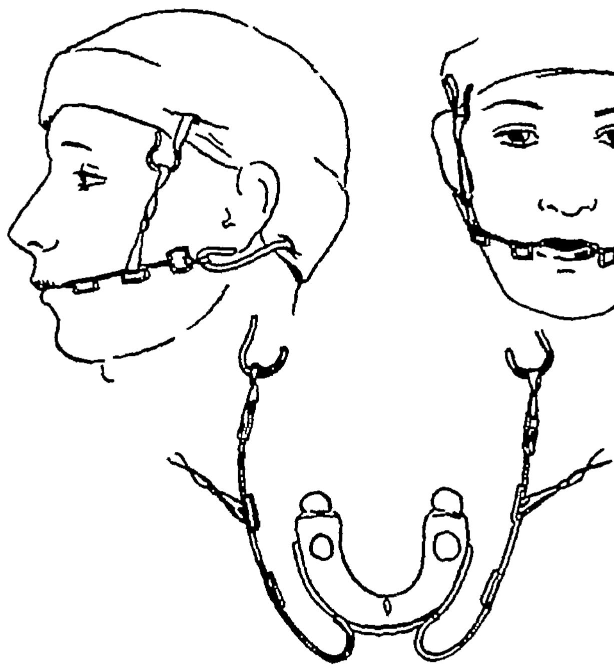


FIG 603 Immobilization of maxillary fracture Metal impression tray, equipped with heavy metal side-arms, attached to upper teeth with stent. Elastic bands stretched between side-arms of tray and hooks built in headgear For details, see text (Ivy)

During the period of immobilization the occlusion is examined frequently and adjusted by elastic traction bands from time to time if necessary The splints are removed in 4 or 5 weeks, but because of the relative slowness of ossification in the upper jaw as compared with the lower, the patient is warned against biting hard objects for several weeks thereafter

Should the *fragments be displaced*, they must be reduced, and this can best be accomplished by gradual elastic traction If the displacement is *downward*, elastic bands are stretched between the side-arms of the dental splint and the lateral extensions on the headgear to force the parts upward In case of comminution with a loss of bone, however, such traction, if allowed to continue, would obviously overcorrect the deformity and thus shorten the face. To prevent this, as soon as the proper amount of reduction has been obtained, the elastic bands are replaced by rigid metal rods with a view to maintaining the dental arch at its proper distance from the base of the skull

Federspiel (69) corrected a *downward displacement* by fixing a #15 gauge half-round German silver wire to the teeth of the upper dental arch by means of wire ligatures (fig 604) Copper wires were then looped around the arch wire in the bicuspid regions on either side. The ends of the wire were threaded on large curved needles and passed through the cheek to emerge externally at points close to the alveolar cul-de-sac. They were then attached to the headgear and tightened daily, until the desired reduction was brought about The small puncture wounds in the skin of the cheek left scarcely perceptible scars

Major (150) employs skeletal traction, as follows A plaster head-cast is applied incorporating a heavy iron wire "with a lug emerging from the cast above and anterior to the tragus of each ear Another smaller wire emerges from the cast in the frontal area. The former wire is used for traction, as discussed later, and the latter is used to attach the spreader to the head cast, as described hereafter

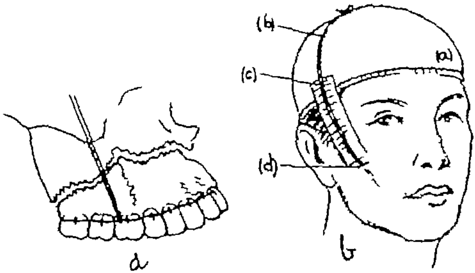


FIG. 604. Reduction and immobilization of maxillary fracture associated with downward displacement. *a*, arch wire #15 gauge attached to teeth. Copper wire fixed to arch at level of first molar to be passed through cheek. *b*, wire passing through cheek attached to plaster head-cast and tightened daily until maxilla is drawn into correct position. *a*, plaster head-cast *b* wire *c* gauze pad *d*, emergence of wire through cheek. (*Federspiel*)

"The mandibular nerve is injected on each side with procaine hydrochloride After topical anesthesia of the mucous membranes of the upper jaw is secured and this deep nerve of the lower jaw is injected, splints are applied to the labial and the buccal aspects of both the upper and the lower teeth. The splints are wired to three or four teeth on each side above and below with double 26 gage stainless steel wire. The splint is provided with lugs at intervals of about 1 cm the lugs on the upper splint being directed upward and those on the lower splint being directed downward. The splints are applied at this time so that, after the fracture has been gradually reduced by skeletal traction rubber bands may be applied between the upper and the lower splint and the finer adjustments made to bring the teeth into their original relations.

"Under sterile conditions a Kirschner wire is now inserted into the symphysis of the mandible. No additional anesthesia is required, since the mental nerve has been anesthetized. A small nick is made in the skin and extended down to the outer aspect of the mandible With a bone drill a hole is started in the mandible at a point one-

eighth inch above its inferior border and one-half inch posterior to the symphysis, so that injury of the mental nerve is avoided as well as injury of the apexes of the teeth After the hole has been started, the Kirschner wire is introduced and is brought out on the opposite side of the mandible at a point corresponding to the point of entrance. This wire lies entirely within the mandible and does not pass through the floor of the mouth, being entirely extra-oral As the wire emerges a small nick is made in the skin. A spreader is attached and dressings applied to the points of entrance and exit of the wire The spreader is brought up to the frontal area and attached to the cast wire in that position Traction is not applied to the spreader itself S-shaped hooks are applied to the Kirschner wire on each side, and similar hooks are placed on the iron wire incorporated in the head cast in the preauricular areas A turnbuckle (32 threads to an inch) is inserted between the two S-hooks on each side, and the slack is taken up by turning the turnbuckle The patient is then returned to his room The apparatus is shown in figure 605

FIG 605 Reduction of maxillary fraction by skeletal traction with Kirschner wire For details, see text (Major, J A M. A, 1938)

"The nurse is instructed to turn each turnbuckle one eighth of a revolution every three hours If the patient complains of pain in the region of the fracture the turning is done more slowly

"After the reduction has been completed, the wire and the spreader are left in place for three or four days, after which the wire, head cast and spreader are removed and rubber bands are applied between the previously placed upper and lower intra-oral splints The splints are worn for an additional period of from three to five weeks, depending on conditions, after which they are removed"

Kazanjian (118) reduced a partial fracture of the maxilla associated with an inward displacement by passing strands of #25 gauge wire around the necks of the teeth in the displaced fragment and those of the adjacent teeth, and bringing the arch into alinement by twisting the ends firmly together (fig 606)

In *transverse fractures* passing through the level of the orbit with a *downward displacement* of the facial skeleton, Gill (85) passes a wire through holes drilled into the

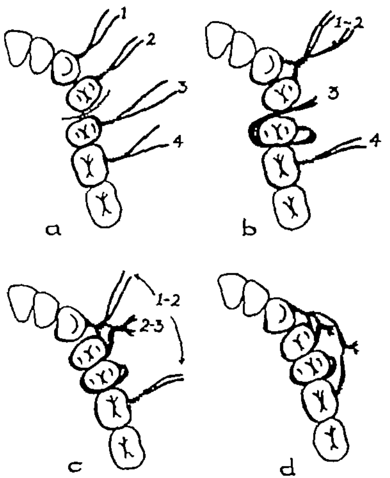


FIG. 606. Reduction and immobilization of fracture limited to alveolus. Strands of #25 gauge wires passed around teeth in displaced fragments and around adjacent teeth. Inward displacement corrected by twisting ends of wires together (Kazanjian)

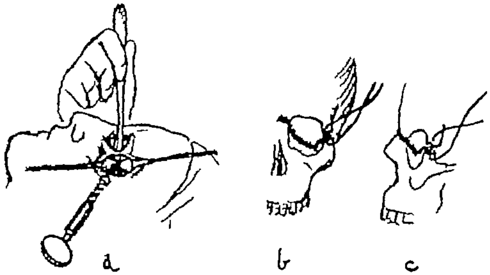


FIG. 607 Reduction and immobilization of transverse fracture passing through orbit, with downward displacement of facial skeleton. *a* drill holes made in angular process of frontal bone and zygomatic process. (Orbital structures protected by blunt instrument passed beneath fragments) *b–c*, frontal and lateral views, showing silver wire passed through drill holes and ready to be tightened. (Gill)

angular process of the frontal bone and into the zygoma below and draws the fragments together by tightening the wires (fig 607). Displacement of the eyeball will correct itself spontaneously when the floor has been adjusted to its proper level

If the maxilla is *displaced backward*, forward traction may be secured by means of elastics passed from a dental splint to a forward jury-mast incorporated in the head-gear Or reduction may be accomplished by the use of intermaxillary traction Properly selected teeth in the molar and premolar regions of the upper jaw and in the incisor region of the mandible are encircled with wires or cap-splints provided with lugs or hooks Elastic bands are stretched between the lugs or hooks of the upper and lower teeth The gradual force exerted by these bands will bring the teeth into their normal occlusal relationships

If the *fracture is limited to a portion of the alveolus*, the fragment is replaced in its proper occlusal relationship and immobilized by means of either an arch-bar bridging the teeth of both fragments, or a metal cap-splint Following fixation the teeth of the unaffected portion of the maxilla are wired to the mandibular teeth (fig 808)

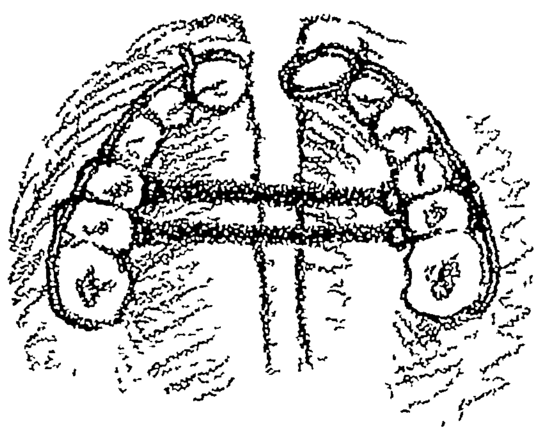


FIG 608 Reduction of palatal fracture associated with outward displacement Arch-bars attached to teeth of both fragments by means of brass wires equipped with hooks on palatal surface Elastic bands stretched between hooks, to bring fragments together (Ivy)

A fracture of the palatal arch with an *outward displacement of the fragments* may be reduced by attaching to the teeth on either side of the fracture separate arch-bars equipped with hooks on their palatal surfaces Rubber bands stretched between these hooks will exert constant traction and bring the fragments into their normal relationships (fig 608) If the *palatal arch has been narrowed* by an overlapping of the fragments, they may be spread apart by means of a jackscrew attached to the teeth of both fragments *Palatal fractures with upward displacement* are easily reduced by passing a sound along the floor of the nose and levering the fragments into position

After-Treatment. The after-treatment is the same as for mandibular fractures and comprises attention to oral hygiene, maintenance of the appliance, dietary management, and general medical care (p 1214)

Secondary deformities, such as scars and tissue losses, require reconstructive operations, but these procedures should not be undertaken until complete healing has taken place and all sources of infection have been eliminated The lost soft parts are replaced with flaps taken either from the vicinity or from a distance (p. 1038). Any bony defects remaining after ossification are best cared for by building out the part with a fascia, cartilage, or bone graft

Management of Fractures of Malar Zygomatic Compound

Fractures of the malar zygomatic compound should be reduced, preferably before swelling sets in. Once the swelling has developed, however, it is better to wait for its subsidence than subject the already damaged tissue to further trauma. In any case the reduction should not be postponed for more than 10 days following the injury, since the bones in this locality undergo rapid ossification, and a permanent deformity may result in a comparatively short time Reduction of the swelling may be hastened by the application of cold compresses or ice bags, and emphysema combated by frequent shrinkage of the nasal mucous membrane with astringents in an effort to maintain the patency of the nasal apertures. If the antrum is involved, ample drainage either through the canine fossa or by way of the middle meatus of the nose, should be provided to allow for the escape of secretions which, if retained, might serve as a convenient medium for the growth of bacteria.

Reduction. Reduction may be accomplished under local or general anesthesia. If the former method is employed, the infra-orbital nerve is blocked in the following manner A vertical line is drawn through the eyelids at a distance of 1 cm. from the inner canthus, another line is drawn obliquely from the nasal spine to the outer canthus. At the point where these two lines intersect the needle is introduced and advanced upward and backward at an angle of 45 degrees to the anteroposterior diameter of the head (174)

The reduction may be effected through various avenues of approach. Obviously, in the case of compound fractures the most convenient route is that by way of the external wound already present. In the absence of such a wound, approach may be gained through the (1) temporal, (2) direct facial, (3) intra-oral, (4) antral, or (5) nasal route

(1) *Temporal Route* The temporal region is shaved and prepared in the usual manner In the hair line just above and in front of the ear a longitudinal incision 3 to 4 cm. long is made down to the temporal fascia. The fascia is then split in the direction of its fibers and a slender bone elevator is passed beneath it. Because the fascia is attached to the lower margin of the malar zygomatic compound, the instrument naturally tends to slip behind the fragments. With the temporal bone serving as a fulcrum, the depressed bone is pried up, guided by the manipulation of the fingers on the cheek. After the reduction the fascia and skin wounds are closed (88) (fig 609) The advantage of this method is that no important structures are endangered, the incision is at a considerable distance from the injured area, and the small scar remaining on the surface is concealed within the hair line.

(2) *Direct Facial Route* The depressed bone may be elevated by passing a tenaculum, a cow horn dental forceps, or a towel clamp through the skin of the cheek, grasping the depressed bone above and below, and raising it into position by traction (85) A straight tenaculum 15 cm. in length, equipped with a Collins slip-lock, may likewise be used for the purpose. The two halves of the instrument are separated, one blade is inserted through the soft tissues above the zygomatic arch, passed behind the bone, and the handle elevated, the other blade is engaged below the bone in a similar manner When both blades have been introduced, they are locked and the depressed fragments elevated into place (178) (fig 610)

The classical method of Matas (162) is still useful. Under procain anesthesia a large

Hagedorn needle threaded with silk is inserted into the skin at a point about 2 5 cm above the midpoint of the displaced fragment and is carried around the posterior aspect of the malar bone, to emerge 1 25 cm beyond its lower margin As the needle is withdrawn, a strand of # 22 gauge copper wire is attached to the silk carrier and made

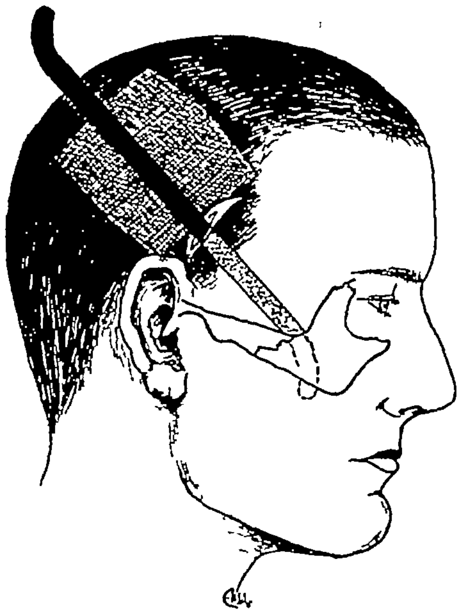


FIG 609 Reduction of zygomatic fracture through temporal route Bone elevator introduced through incision in hair line of temporal region and passed beneath fascia behind bone fragments With temporal bone serving as fulcrum, depressed fragments pried up (Gillies, Kilner, and Stone, Brit. J Surg , Vol 14)

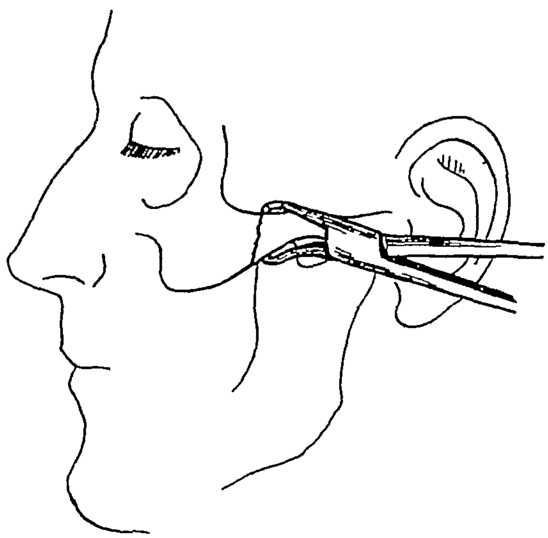


FIG 610 Reduction of zygomatic fracture through direct facial route One blade of tenaculum, equipped with Collins slip-lock, passed through soft tissue above bone, other blade engaged below Instrument locked, and bone elevated into position (Patterson)

to follow the track of the needle The ends of the wires are twisted together, and traction is exerted upward and inward until the bone is brought into its normal position If the fragments tend to slip out of place, the wire may be tied over a glass slide the ends of which are made to rest against firm portions of the bone

Another method envisages the passing of a corkscrew-shaped instrument into the

bone through a stab-wound in the overlying soft tissue and using it as a lever to elevate the fragment (195)

New (171) prefers to "elevate the displaced fragment by means of a hook passed below the fragment through a small nick in the skin. The hook employed is a sharp one, which may be one of various sizes, made of heavy steel wire, with a ring bent at the distal end of the handle on the opposite side to the hook and on the same plane as the bend in the hook itself so that the surgeon always can know the plane of the hook when it is in the cheek. The advantage of the hook over other methods usually employed, such as various types of elevators, and so forth, is that if there is a great deal of comminution and the bone does not become fixed and held in position after it has been elevated then gauze may be fixed around the hook between the skin and the ring of the handle in order to hold the elevation until some fixation has resulted"

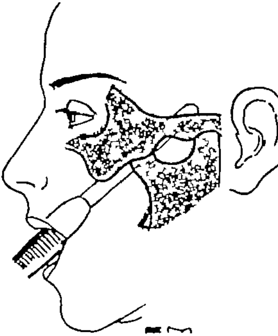


Fig. 611 Reduction of zygomatic fracture through intra-oral route. Elevator introduced through incision in gingivobuccal fold, and carried beneath malar bone. With maxilla acting as fulcrum fragments pried up aided by external digital manipulation

(3) *Intra-Oral Route* After the usual aseptic preparation of the buccal cavity and anesthesia the cheek is retracted, and a small incision is made on the affected side in the gingivobuccal fold above the second molar tooth Through this incision a strong elevator is introduced and carried beneath the malar bone, the instrument being kept close to its under surface. With the maxillary bone acting as a fulcrum, the depressed fragments are pried up, aided by digital manipulation from without (fig 611) (90 221) While this method of approach has the advantage of leaving no external scar it entails the danger of stirring up latent infection

(4) *Antral Route* The cheek is retracted and an incision made in the gingivobuccal sulcus between the second premolar and first molar tooth, the soft tissues being separated as far as the anterior wall of the antrum which, if not already fractured, is opened with a chisel and mallet. Bone fragments are removed blood-clots are evacuated, and the cavity is irrigated with normal salt solution A heavy curved urethral sound

is then introduced, and the bones are levered into position with the aid of external digital manipulation (29, 144, 168)

(5) *Nasal Route* This avenue of approach is especially recommended for cases where removal of blood from the antrum is required Through an intranasal antrostomy a Ritter sound is inserted, and the bones are levered into position (210)

Watkins (230) employs the following technic (fig 612) "Vertical incision is made in nasal fossa from immediately above and in front of the anterior extremity of the inferior turbinate to well on to the floor of the nose The incision is carried as deep as the antromedial border of the maxilla, which is then bitten away with strong forceps and the bony opening is carried back into the inferior meatus The clot in antrum is displaced by packing with vaseline gauze, and when it has been displaced gauze is withdrawn An elevator is then inserted and the body of malar elevated into position In the event of such an elevator not being available, the handle of a teaspoon with a

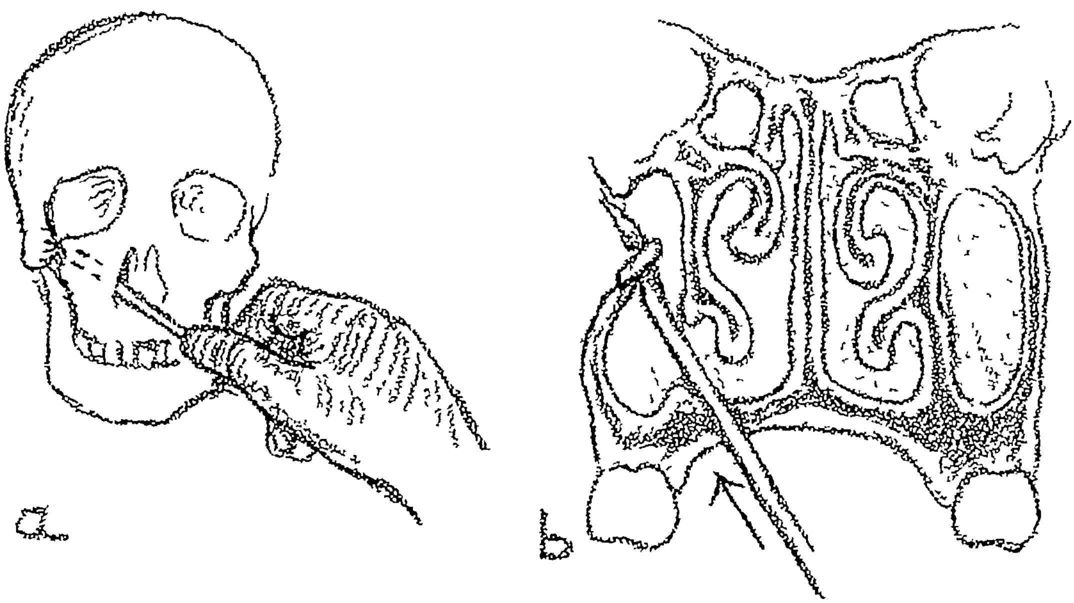


FIG 612 Reduction of zygomatic fracture through intranasal route *a*, bone elevated through intranasal antrostomy *b*, sectional view For details, see text (Watkins)

narrow upper end can be used unless impaction is unusually firm The end of handle is inserted into the antrum so its surface is horizontal with patient in anatomic position It is then turned so that the surface is vertical"

Immobilization. After the reduction of simple depressed malar fractures the serrated bone edges interlock and automatically fix the fragments in place, and since there are no powerful muscles attached to the bones in this vicinity, there is little danger that the displacement may recur Hence fixation is as a rule unnecessary But in comminuted fractures some form of immobilization is usually required

Kazanjian (119) drills a small hole through the displaced bone just below the infra-orbital ridge, and through this aperture he passes a loop of #25 wire, causing it to emerge through the skin just below the lower eyelid The ends of the wire are twisted together and bent to form a hook, which is attached by means of a small elastic band to a heavy #8 wire suspended from a headgear (fig 613) The traction secured by this elastic force is directed upward and outward At the end of a week the wire loop in the bone is removed

Akerman (1) makes an incision over the zygoma, drills a hole into the bone fragment, and introduces a conical thread screw 5 cm long and 1.5 mm. wide. By exerting traction on the screw he reduces the fragment and maintains it in place by means of an elastic band passed between the end of the screw and a steel wire embedded in a plaster head-cast.

Fixation may also be obtained by packing the antrum with iodoform or vaselin gauze and leaving it in place for 2 or 3 days. Blair (29) advises that the packing be allowed to remain for 2 or 3 weeks and incorporates Dakin tubes for purposes of drainage and irrigation during the period. If the intranasal route was used to secure the reduction, the gauze is introduced through the nose.

FIG. 613 Immobilization of comminuted zygomatic fracture. Loop of #25 gauge wire passed through drill hole in bone and carried through skin. Loop attached by elastic to a #8 gauge wire embedded in head cap, in a manner to secure upward and outward traction. (Kazanjian)

In the case of extensive fractures direct wiring of the fragments may be necessary to secure the required immobilization.

Management Following Organization of Fragments in Faulty Position. If for some reason the fractured bone was not reduced at the time of injury and union took place in a faulty position, refracturing and repositioning of the bone may be called for to eliminate the resultant deformity and disturbance of vision. Should there be scars in the overlying soft tissues, their excision will furnish convenient access to the bone, but in the absence of such scars recourse may be had to the same avenues of approach as are used in the reduction of a recent fracture. Occasionally, more than one avenue will have to be employed. When the bone has been exposed, the old fracture lines are opened up with a thin bladed chisel and mallet, and the fragments manipulated into their normal positions and treated in the same manner as a recent fracture. The wound

of entry is then closed without drainage, and a dressing is applied Osseous union may be expected in about 3 weeks

If there has been an actual loss of bone, the deformity is corrected and support to the eye furnished by a plastic procedure to be described later (p 1044)

FACIAL INFECTIONS

Infections of the face are *common* While it is true that the great majority of them are essentially self-limited, resolve spontaneously, cause but slight annoyance, and produce no alarming sequelae, it is also true that infections in this locality, especially

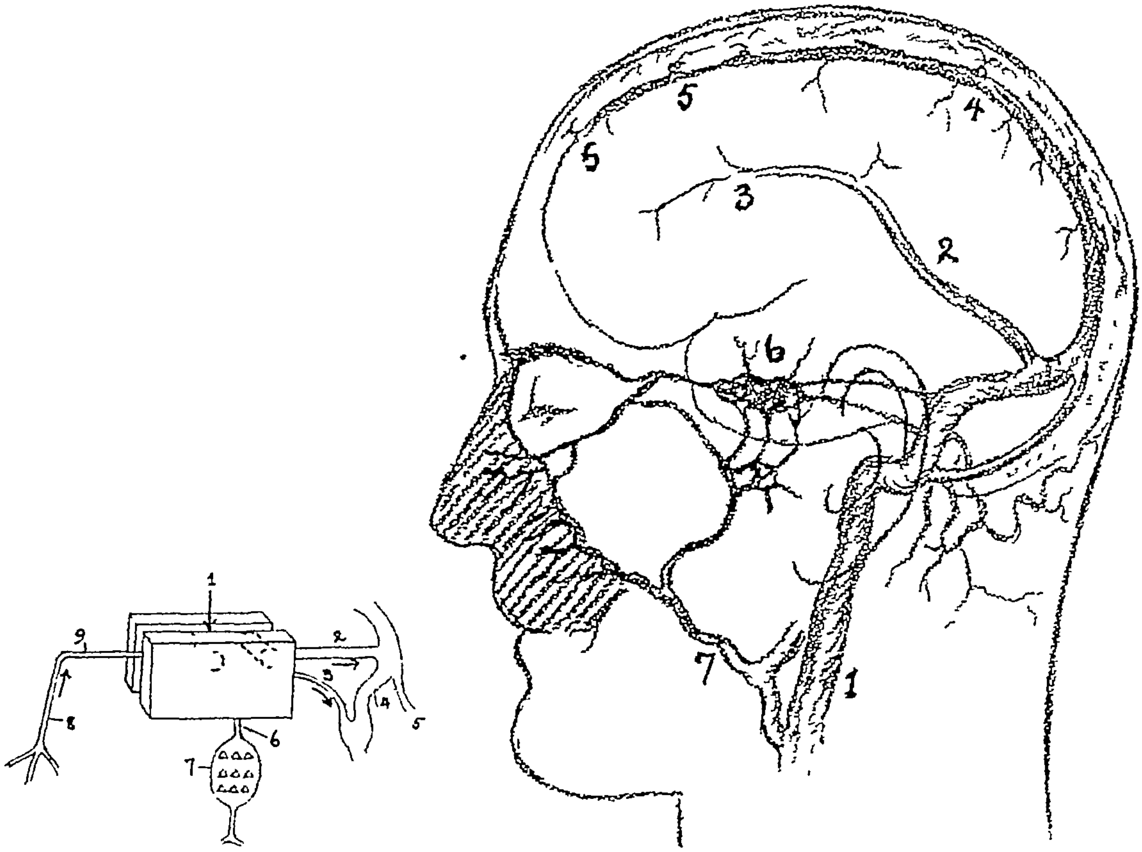


FIG 614 Relation of facial veins to veins of interior of skull *1*, internal jugular vein, *2*, straight sinus, *3*, inferior sagittal sinus, *4*, superior sagittal sinus, *5*, diploic veins, *6*, cavernous sinus, *7*, anterior facial vein (Cutler) Insert, schematic representation of communications of cavernous sinus *1*, circulocavernous sinus, *2*, superior petrosal sinus, *3*, inferior petrosal sinus, *4*, lateral sinus, *5*, mastoid emissary vein, *6*, emissary vein through foramen Vesali—or, when absent, through foramen ovale, *7*, pterygoid process, *8*, angular vein, *9*, superior ophthalmic vein (Bailey)

in the vicinity of the upper lip, are potentially dangerous and often take a fatal course The first to call attention to the seriousness of the condition was Ludlow (146) who in 1852 described 6 cases, 3 of which ended in death The greater tendency on the part of furuncles to become malignant when situated on the face than when encountered in other parts of the body has been explained from both a bacteriologic and an anatomic standpoint, but neither explanation is entirely satisfactory

The first to stress the bacteriologic origin of the condition was Stromeyer (222) (1855) who advanced the opinion that the facial lesion was but a local manifestation of a generalized infection This conception held sway until 1886 when Trendelenburg

(225) suggested that it was due to a specific organism But up to the present time no such organism has been isolated The bacteria usually found are the staphylococcus aureus (136) and the streptococcus (126), particularly the hemolytic variety

The anatomic origin is explained on the basis of (1) the peculiarity in the distribution and structure of the facial veins (2) the thinness of the skin and its loose subcutaneous tissue and numerous lymph vessels and (3) the absence of fascial planes in the facial muscles (200) The collecting venous plexus of the *lips* nose, chin, *eyelids, and fore* head is in direct communication with the interior of the skull (fig 614) (a) by way of the angular vein, which drains the transorbitalis, which in turn communicates with the cavernous sinus, and (b) by way of the deep facial, which communicates with the sinus through the pterygoid plexus. Structurally, the facial vein is devoid of valves and resists collapse by virtue of the network of fibrous tissue surrounding it. In the event of venous obstruction by an exudate or a thrombus, the absence of valves in the facial vein permits infection to reach the cavernous sinus either by a retrograde progression

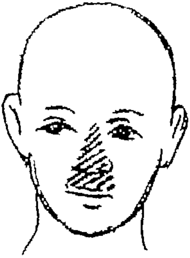


FIG. 615 "Dangerous area" of face.

through the angular and superior ophthalmic veins or by a more circuitous course through the deep facial veins and pterygoid plexus The skin of the face differs from that of the rest of the body in that it is thin gives attachment to muscles, and participates in facial expression Thus the constant movement aids in the dissemination of septic material into the loose subcutaneous areolar tissue which is not constituted to resist infection. The absence of fascial sheaths in the facial muscles prevents the localization of the infective process and their constant movement interferes with the splinting power of the surrounding parts

Clinical Features

The benign infections of the face are essentially self limited, run the usual course of infection elsewhere and will therefore not be described in these pages. The malignant or virulent type is prone to occur within a triangular space with its base extending between the angles of the mouth and its apex at the glabella—a region which has come to be known as the "dangerous area" (fig 615) An infection innocuous elsewhere in the body is fraught with the gravest dangers when encountered in this location

The history usually given in those cases in which the clinical picture changes abruptly from a mild infection to one that is rapidly fatal is one of slight trauma, such as is caused by an attempt to abort a furuncle by squeezing, by injudicious incision, or by the introduction of antiseptics In the first stage of the infection the symptoms are those of an ordinary furuncle or carbuncle The second stage is marked by a rapid extension of the process A wide area of the adjacent tissue becomes swollen, edematous, and indurated, the face assuming huge proportions The lip is enlarged to two or three times its normal size, so that the mouth is opened with difficulty, and the lids become so swollen as to close the eye The temperature rises rapidly, and toxic manifestations of delirium, chills, glycosuria, and coma soon follow Pain is at first severe, due to the pressure of the exudate, but it subsides as toxemia develops In a comparatively short time thrombophlebitis appears, and the veins can be felt beneath the skin as thickened cords Finally, septicemia, meningitis, and cavernous sinus-thrombosis, manifested by evidences of intracranial pressure, exophthalmos, and paralysis of the ocular muscles, supervene and herald the onset of a fatal termination The mortality varies in different clinics from 8 per cent (Bier's clinic) to 10 per cent (59, 106, 109)

Management

Prophylactic treatment is obviously important Infections about the face, especially within the "dangerous area," should not be traumatized by unnecessary palpation, squeezing, picking, or incisions, as these manipulations break down the wall of leukocytes upon which the limitation of infection depends The area should be protected against mechanical irritation and carefully watched, and at the slightest sign of a spreading of the condition the patient should be placed in a hospital Havens and MacKay (97) write. "When a pustule appears about the face, the average person's first impulse is to pick it open and squeeze it When a patient consults his doctor about a 'boil' on his face, too many times the lesion is promptly incised and, all too frequently, squeezed vigorously 'to get out the core' A number of writers have stated that they never have seen a fatal case in which there was not a history of 'picking' or otherwise traumatizing a pimple or furuncle Laymen should be instructed not to pick at small pustules on the face If a patient consults his physician regarding a large pimple or small furuncle, he should be instructed as to its possible danger"

In the case of benign facial infections all surgeons agree that conservative treatment is best, but in the malignant varieties, a considerable percentage of which end fatally, there is an irreconcilable difference of opinion as to the proper management In this regard Maes (148) writes "The chief trouble is that few surgeons see enough cases to arrive at any conclusions on the basis of their own experience They save or lose one case by some method of treatment and they endeavor to formulate rules on the basis of that case only" One school of thought (24, 59, 106, 125, 167) believe that operative measures are superfluous, if not actually dangerous, and advocate conservative treatment They do not believe that even virulency is an indication for operation They point out the fact that as soon as the necrotic process is walled off, it will be spontaneously expelled, that incision at best exerts a decompressing effect of only a few millimeters, opens up adjacent lymphatics for the spread of infection, retards healing, and interferes with the production of antigens at the site of infection In this connection Morian (167) states that incision gives no better results than conservative

treatment and has the disadvantage of leaving a disfiguring scar Those that lean toward conservative treatment sustain their contentions by statistics. Thus Dittrich (59) found that in furuncles of the upper lip treatment by operation resulted in a mortality of 13 6 per cent, while similar cases treated conservatively showed a mortality of only 5.5 per cent.

Another school, presenting equally convincing figures, advocate early radical operation In an effort to evaluate the comparative benefits of conservative and radical treatment, Ayres, Anderson, and Foster (9) sent a questionnaire "to 250 dermatologists and to an equal number of surgeons. Dermatologists, it seems, tend toward conservatism in the treatment of carbuncles, whereas surgeons are more inclined to use radical procedures. The majority of surgeons employ crucial incisions or cautery excisions of carbuncles, whereas the majority of dermatologists employ conservative methods, including X rays, vaccines, bacteriophage and topical applications The mortality from carbuncles is low in both groups, but it is more than three times as great under surgical as under dermatologic treatment." But inasmuch as surgical management is charged with the greater percentage of hopeless cases, the statistics advanced are not entirely dependable, and it is therefore difficult to evaluate them.

In recent years surgical opinion as to treatment has veered toward conservatism.

General Treatment

The constitutional treatment aims at increasing the patient's resistance to the infection by maintenance of the fluid balance and promotion of elimination Sedatives are administered for the purpose of allaying restlessness and relieving pain Ancillary contributing conditions, such as anemia, hyperglycemia, and malnutrition, are investigated and the appropriate treatment instituted (Chapter VIII) In view of the known relationship between furunculosis and a disturbance of carbohydrate metabolism (10, 182), dietary measures designed to lower the blood-sugar are prescribed. Bieber (23) prescribes 2 units of insulin daily for 4 days, Stoermer (218) likewise employs insulin, but in much larger doses—i.e , 20 to 80 units. Small repeated blood transfusions of 250 cc. every other day are of decided benefit. Attempts have been made to attack the cause specifically by the use of staphylococcic vaccines (both autogenous and stock), toxoids (124, 215, 229), and the intravenous administration of immunized blood. Sulphanilamid, although not considered effective against the staphylococcus, is indicated on the basis that the streptococcus may be the exciting factor (p 280) Foreign proteids have been injected into the gluteal and deltoid regions with the hope that they might increase the production of specific protective bodies. While it is true that isolated instances of spectacular success have been reported following specific therapy, nevertheless these measures on the whole have proved disappointing

Local Conservative Treatment

In the case of simple localized infections no special treatment is required, since the condition is self limited and will subside as soon as a protective wall is built around the infected site. If the swelling spreads and the temperature rises, the patient should be confined to bed, preferably in a hospital, and the activity of the part minimized as

a precaution against dissemination of the infection The individual is isolated, so that there may be no temptation to talk, and food is administered in the form of liquids —by gavage, if possible—to do away with the necessity of mastication The affected part is splinted well beyond the indurated area with strips of elastoplast If the lesion is on the upper lip, both lips and the cheek on the affected side are strapped (176) To allay restlessness and relieve pain, sedatives are administered

In addition to the above measures innumerable forms of therapy have been suggested, among which are the circuminjection of the patient's own blood, surface applications, and Roentgen and ultraviolet irradiation The injection of autogenous *whole blood* aims to wall off the infection with blood cells (132) and thus prevent its spread From 40 to 80 cc of blood are withdrawn from the median basilic vein, and a series of injections 2 cm apart are made around the indurated area In order that the blood may be distributed more evenly, Kuhn (130) has suggested the use of a vacuum cup applied at an initial negative pressure of 100 to 200 mm of mercury, subsequently increased to 400 to 600 mm , the cup being left in place for ½ to 4 hours

While many favorable results have been reported following the local injection of autogenous blood (47, 102, 205, 206), it is difficult to rationalize its benefits It would seem that such a wall of dead cells would act as a culture medium for the bacteria and place an added strain on the tissues struggling to remove the dead foreign bodies

The purpose of *surface applications* is to relieve pain, act as antiseptics, soften the skin, and accelerate the discharge of the central necrotic area Among the antiseptic dressings advocated are those consisting of 90 per cent alcohol, 20 to 30 per cent mercurial ointment, and aluminum acetate To macerate and soften the skin over the furuncle and thus favor the evacuation of pus, digestants composed of enzymes of the pancreas have been applied in the form of salves Probably the simplest and most effectual compress is one wrung out of a hot hypertonic salt solution (46), boric acid, or magnesium sulphate, placed over the affected part, and covered with cellophane, the whole being overlaid with an electric heating pad Friedemann (76) claims good results with Bier's (24) method of inducing passive hyperemia, by constricting the superficial veins of the neck over a period of many hours daily

Roentgen and ultraviolet irradiation have both been used in the treatment of malignant furuncles, on the grounds that they abort infection, hasten the process of healing, and decrease pain Manges (156) employs 10 to 20 per cent of a skin erythema dose of x-ray or from 60 to 120 R units of from 80 to 135 KV with unfiltered or light filtration Hodges (104) uses 100 to 150 R units of unfiltered low voltage rays The favorable action of irradiation is thought to be due to its breaking down of the lymphocytes, the antitoxic substances thus liberated destroying or neutralizing the bacterial and other toxic products (58) On the other hand, Carp (47) believes that the detrimental effects of irradiation therapy outbalance its benefits, since it interferes with the multiplication of the cells which under normal conditions would wall off the infection

Surgical Treatment

Those who favor radical treatment advise operative intervention as soon as signs of malignancy appear, and believe that the indication is imperative, regardless of the patient's general condition Diabetes or even pyemia is not considered a contraindication The problem here, however, lies in determining whether or not the particular infection is destined to become malignant, and this is difficult, since the transition

between the benign and malignant types is not clearly defined, and it is not unusual for a benign furuncle to give rise to symptoms, general as well as local, similar to those characteristic of the malignant variety Bailey (11) believes that "a sign which foretells impending danger is spreading edema from the lip to the inner canthus and this is usually found in the presence of suffusion of the eyelids. As far as my own observations have gone, the premonition is invariably unilateral. If in addition to this sign there is considerable elevation of temperature the call for action is imperative.'

Numerous operative procedures have been advocated—notably incision and excision of the infected focus ligation of the angular vein as a precaution against extension of the septic process into the cavernous sinus, and, in case of sinus thrombosis, surgical attack on the sinus itself

Those who advise *incision* suggest that irrespective of the resultant deformity the part be opened widely and radically, for the purpose of preventing dissemination of pus into the surrounding tissues. The type of incision to be employed seems to be of minor importance, provided it permits of adequate drainage. The part is opened under general anesthesia, inasmuch as the injection of a local anesthetic not only would be as painful as the incision itself, but would entail the danger of spreading the infection. The incision is made preferably along the mucocutaneous margin of the lip, so that there may be a minimum of subsequent scarring but should this not provide sufficient drainage it is made along the outer or inner surface of the lip, depending on the site of the induration A cautery knife is preferable to the scalpel, as it requires less pressure, does not cause such extensive bleeding diminishes the absorption of lymph by occluding the lymph spaces, and incurs less shock.

Sébileau (209) suggested *ligation of the angular vein* on the affected side, as a precaution against extension of the infective process into the cavernous sinus, and the procedure has been adopted by many surgeons (11, 42, 197) Under local anesthesia a short incision is made, extending from a point just below the inner canthus along the nasobuccal groove The angular vein which lies beneath the fibers of the caput angulari is tied off Roeder (198) has constructed a compression device designed to block off the angular vein and claims benefits equal to those obtained from ligation While theoretically ligation is justifiable, in actual practice it finds little application. To be of value, the procedure must be carried out early, and if done routinely, it would obviously entail many unnecessary operations. If done late, the necessary manipulation would be likely to liberate infected emboli. Maes (148) states that he has never seen an early case in which he considered ligation was indicated nor a late case in which it would be of any benefit.

When the infection has invaded the cavernous sinus the condition is usually fatal although successful surgical cures have been recorded (38, 61) Havens and MacKay (97) 'believe that the risk of operation for drainage of the cavernous sinus in these cases is so great that it can only be in the exceptional case that the prospect of benefit is sufficient to warrant assuming the risk.

Christopher (50) outlines Chiari's (49) treatment of lip furuncles as follows '*Mild cases* (1) heat, (2) rest, (3) prohibition of speech, (4) fluid nourishment, (5) with the appearance of fluctuation, a small incision with the cautery *Transitional cases* (1) autogenous blood injections (2) simple central cauterization (3) hyperemia, (4) special heat. *Severe cases* (1) autogenous blood injections, (2) hyperemia, (3) splitting thermocautery incision (within the infected area) '

OSTEOMYELITIS OF FACIAL BONES

There is considerable difference of opinion as to the actual meaning of the term "osteomyelitis" when applied to the facial bones Originally, the designation was limited to an inflammation of the medullary canal and the adjacent bone, but it has since come to include many different forms of bone infection, such as panosteitis, periostitis, osteoperiostitis, osteitis, periosteomyelitis, and local forms of alveolar inflammation According to the resolution of the German Society of Dental Anatomy and Physiology, every acute or chronic inflammation of the paradentium should be regarded as osteomyelitis For the sake of convenience, however, the term will be made to apply only to cases presenting the picture of bone-marrow inflammation The disease is always serious It is followed by prolonged invalidism, impairment of function, gross facial deformity, and, in the case of children, interference with osseous development

Pathogenesis

Of all the bones attacked by osteomyelitis those of the jaws rank eighth in frequency In adults the mandible is affected more often than the maxilla in the ratio of 4 to 1 (234), but in children the reverse is true, probably because of the greater sponginess, the larger cancellous spaces, and the greater vascularity of the upper jaw The other bones of the face are rarely involved Males are three times more prone to osteomyelitis of the face than are females (40) Although no age is exempt, the disease is most common in individuals between 20 and 40, probably owing to the greater number of operative procedures on third molars, impacted or otherwise, at this time of life. The etiologic factor is some form of pyogenic organism, but there is no general agreement as to the particular germ predominating Those most frequently encountered are the staphylococcus pyogenes aureus (181), the staphylococcus pyogenes albus, the streptococcus pyogenes, and the pneumococcus

Mode of Extension

The organism may reach the bone (1) directly, or (2) by way of the blood stream

(1) **Direct Infection.** In the majority of cases osteomyelitis of the facial bones is odontogenous in origin and consequent upon (a) Periapical or dento-alveolar abscesses, impacted third molars, and, in the case of infants, extension of infection from the follicles of unerupted teeth (b) Faulty dental extractions in the presence of acute inflammation, especially when the extraction is followed by curettage and packing of the alveolar socket If hydrogen peroxid is employed in the packing, the danger of infection is said to be increased, because the bombardment of oxygen gas in the enclosed space may drive the septic material into the cancellous bone tissue (c) Injection of a local anesthetic into infected tissue, and operative procedures in which the periosteum has been stripped from the bone to such an extent as to impair its vitality Direct infection of the facial bones may also be brought about by accidental trauma, which may vary in extent from an insignificant wound inflicted on the gum by a toothpick to a compound fracture of the facial bones Less commonly the organisms gain entrance by direct extension from surrounding structures, notably the cheek, lips, and gums

(2) **Infection by Way of Blood Stream.** Infection may be carried to the facial bones as a metastatic lesion by way of the blood stream either during or as a sequela to, a transient circulatory infection. This mode of transmission is rare in adults but not uncommon in infants and children because of the sponginess and vascularity of the bone which renders it more susceptible to infection than the dense, compact bones of older individuals

Pathology

Osteomyelitis is essentially a thrombo-embolic process which ultimately advances to the stage of bone necrosis and sequestration The pathologic findings in the facial bones differ from those encountered in long bones due to the peculiar anatomy and blood supply of the former The facial bones are structurally ill adapted for the encapsulation and localization of infection and in many places, such as around the alveoli, they are exceedingly thin, a fact which explains the ease with which pus finds admittance into the subperiosteal tissue. Moreover, unlike long bones, they receive their blood supply through arterial loops derived from a single vessel.

Upon the size of the vessel and the facilities for drainage depends the amount of bone destruction When the infected thrombus occludes a small vessel and drainage is free, the sequestrum is usually small and of little importance, but when drainage is impaired or a major trunk is involved, a large amount of bone is apt to sequestrate. The blood supply of the superior maxilla is derived from the infra-orbital, ethmoidal, alveolar, palatine, and frontal branches of the internal maxillary artery and from the nasal and palatal branches of the external maxillary Thus, when the main trunk of the internal maxillary artery becomes blocked, loss of the entire maxilla on the affected side may result whereas an infected thrombus of the infra-orbital artery will cause necrosis only of the orbital and nasal aspects of the bone, occlusion of the dental and gingival arteries will be followed by destruction of the alveolar process, and involvement of the palatine arteries will lead to loss of the palate. The mandible receives its blood supply from the inferior alveolar, inferior labial, and coronary arteries. In addition, it is nourished by the periosteum and overlying soft tissues If the inferior alveolar artery is involved, the main part of the intramedullary portion of the mandible will be lost, although a thin shell of bone next to the periosteum frequently escapes damage by virtue of the nutrition it receives from the periosteum. The condyle and coronoid process rarely undergo necrosis, since their blood supply is derived principally from the surrounding soft parts. Generally speaking, the mandible because of its greater density, is more subject to necrosis than is the maxilla.

When the suppurative process perforates the cortex of the bone, its extension will be governed by the muscular attachments, fascial planes, and blood supply of the affected bone. In the maxilla the most common location of abscesses is in the vicinity of the zygoma and orbit. Less common sites are the nasal, palatal, orbital, and antral regions. In the mandible the abscess may form in the alveolar region, in the floor of the mouth, or in the neck. From the latter region the spread of infection is determined by the fascial planes. If the pus descends into the posterior cervical triangle, the superficial layer of the cervical fascia will prevent its extension to the surface, and it will therefore tend to advance underneath the trapezius posteriorly the sternomastoid in front, and the clavicle below until checked by the union of the cervical fascia with

the costocoracoid membrane If in the anterior triangle, it may find its way into the thorax and progress as far as the pericardium, but it usually points above the sternum, owing to the fact that the fascia in this location is thinner and less compact in structure

After 12 to 15 weeks the sequestrum loosens and is often spontaneously extruded The healthy surrounding bone responds to the continued irritation by laying down new bone in the form of an involucrum Since involucra are dependent for their formation upon periosteum, they are scantily formed in the maxilla, due to the poor development of the membrane in this location, but in the mandible with its well-organized periosteum involucrum production is abundant As long as the dead bone remains in place, sinuses will persist in the soft tissues When it has been spontaneously expelled or removed, there remains a defect in the bone which, if small, becomes filled in with scar tissue, causing little residual deformity If, however, a large section of bone has been destroyed, extensive disfigurement and functional impairment are apt to result, and, in children, there is in addition a retardation of growth

Clinical Features

The clinical picture will vary in accordance with the nature of the infection and its location In the acute stage 2 or 3 days are required for the interior of the bone to break down, and during this period there will be no visible or palpable signs of inflammation In time the pus breaks through the cortex of the bone and drains either internally into the mouth or externally onto the skin The face and lips become swollen and painful, the gums soften, and the teeth successively loosen, pus exuding from around their necks Sinuses form which respond to palpation as fibrous cords, and through them the necrotic bone may be felt with a probe When the maxilla is involved, redness and swelling of the eyelids and the periorbital tissues result, accompanied by a purulent conjunctivitis The periorbital distention frequently becomes so severe as to give rise to exophthalmos The abscess usually points below the inner canthus, leaving a fistula discharging on the face If the infection is in the mandible, the inflammation and swelling are evidenced in the tissues of the lower face and neck The lymph-glands are enlarged and sensitive to the touch, subcutaneous abscesses are common because of the proximity of the skin to the bone, movement of the tongue becomes restricted, and in consequence speech and mastication are impaired

The constitutional manifestations are the same as those observed in osteomyelitis involving other bones The temperature rises and remains elevated until drainage becomes established If the infection has reached the facial bones by way of the blood stream, the symptoms are usually masked by those of the causative condition The clinical features are those of acute sepsis, the patient sometimes becoming alarmingly toxic The acute stage subsides in about 10 days to 2 weeks with a lessening of the local inflammation and a fall of the temperature by lysis This is followed by a chronic stage characterized by a long period of drainage accompanied by necrosis, sequestration, and involucrum formation

X-ray studies of the affected bone during the first 3 or 4 days of the acute stage afford little information and may give rise to a false sense of security, since at this period of the infection the cortical changes are not sufficient to interfere with the passage of the ray. Therefore at this time one must depend for the diagnosis upon the clinical signs and symptoms After a week or two, however, the calcium salts become absorbed,

and roentgenographic examination is then of inestimable value in the outlining of necrotic bone, sequestra, and involucra.

Osteomyelitis of the facial bones can be differentiated from acute leukemia and agranulocytic angina by means of blood tests. Actinomycosis may be ruled out by its slow onset and the isolation of the ray fungus Infected cysts or odontomata often give rise to acute symptoms, but the roentgenogram will demonstrate the lesion Other conditions that might be confused with osteomyelitis are apical and marginal peridontitis, apical granuloma, acute alveolar periostitis, osteitis fibrosa carcinoma, and sarcoma.

Treatment

Despite much clinical and experimental investigation on the subject, there is still considerable difference of opinion as to the proper management of the acute phase of osteomyelitis of the facial bones. There are those who aim to abort the disease by early radical surgery (62, 78, 96) but experience has demonstrated that such treatment is productive of much harm. Hence, most clinicians favor conservatism (28) But whether radical or conservative measures are employed (6, 60, 234), a long-drawn-out course is inevitable.

Local Treatment

The local treatment includes (1) *drainage*, (2) *removal of dead bone*, and (3) *plastic operations* for the reconstruction of the residual deformity

(1) **Drainage** While the benefits to be derived from surgical drainage are generally admitted, great discrimination must be employed in the choice of the proper time for its institution. Premature drainage will not decrease the amount of local destruction nor limit the systemic manifestations instrumentation of the bone before the infection has lost its virulency may encourage the extension of the necrotic process and, furthermore the shock of operative trauma and the interference with the defensive body mechanism struggling to overcome the septicemia may jeopardize the life of the patient (74) Watchful waiting for a day or two allows time for the development of the necessary general resistance and localization On the other hand, however should drainage be too long delayed, there is apt to result extensive destruction of the bone absorption of toxins, and septicemia. The weight of opinion favors the inauguration of surgical drainage as soon as the infective focus has become localized Meanwhile, the jaws should be immobilized fomentations applied, and supportive treatment instituted

In odontogenic cases, if the infection is still in the dental pulp or pericemental membrane all that may be necessary to cause a resolution of the entire process is the extraction of an offending tooth. If pus has invaded the deeper tissues, however, removal of the tooth cannot be expected to effect drainage and may even aggravate the condition by the trauma induced. Teeth which are merely loosened should not be sacrificed since after the acute symptoms have subsided they will again tighten up If a dento-alveolar abscess is present, it is drained through a horizontal incision beginning above the roots of the affected teeth and extending beyond 2 or 3 of the teeth adjoining the original site of the infection. Occasionally it may be necessary to carry the incision across the entire alveolar arch. Pain is relieved by the application of an ice bag or the administration of a sedative.

More complicated cases demand more extensive drainage, and this must be instituted with the least possible operative trauma and a minimal loss of blood Rough manipulation, indiscriminate drilling or chiseling, or too vigorous sponging may dislodge infected emboli and give rise to secondary lesions The periosteum is exposed through an intra- or extra-oral incision, depending upon the localization of the infection The membrane may appear normal, it may look swollen and reddened, or it may be lifted up by a definite abscess, but regardless of its appearance, it should be incised to expose the underlying bone If the bone shows no apparent involvement, nothing further need be done, but if it is inflamed or appears dull white and dead, or if pus exudes from it, the bone itself requires drainage, and here the question arises as to how extensive the operative procedure must be, in order to furnish adequate drainage The most practical procedure is to raise a mucoperiosteal flap and open the medullary cavity by drilling several holes 3 mm in diameter through the cortical surface of the bone with a dental burr or a fine chisel These openings serve to relieve tension, prevent massive necrosis, and permit the tissues to wage their own battle As the abscess develops, it will discharge through these apertures into the overlying dressings rather than into the cancellous tissue After provision has been made for drainage and hemostasis attended to, the wound is gently irrigated, sponged dry, and kept open by means of a light pack of sterilized vaselin gauze carried for a short distance beyond the wound edges to prevent maceration of the skin The part is then covered with a dry dressing and the jaws immobilized, to obtain physiologic rest and prevent deformity After a week or 10 days the wound is cleansed, irrigated, and repacked If healing has been satisfactory, the cavity will be found lined with granulation tissue and appreciably reduced in size More extensive operations, such as subperiosteal resection of the cortex of the bone and "guttering," are not advisable, since at this stage it is practically impossible to determine the exact limits of infection and necrosis, and such procedures would tend to spread the infection by the implantation of infected material into healthy bone.

Except in the hematogenous type of infection, in which the bone involvement is only a local manifestation of a general blood infection, adequate drainage will frequently result in a dramatic subsidence of the clinical signs and symptoms, manifested by a drop in temperature and relief of pain Any subsequent elevation of temperature indicates either an interference with drainage or the presence of a metastatic focus in another part of the body If drainage is obstructed, the packing should be removed and the wound re-dressed, if the cause is metastatic infection, the part is treated in a manner similar to the initial lesion

Abscesses in the soft tissues are drained intra- or extra-orally, depending upon the direction in which they point The incision should be so planned as to avoid injury to adjacent important structures and yet provide for adequate drainage (fig 616) In cases where the pus has spread into the orbital cavity, drainage is provided by way of an incision beneath the eyelid Accumulations of pus in the antrum are removed through the anterior wall or through an alveolus In the lower jaw abscesses that form above the level of attachment of the mylohyoid may be drained from the mouth, but those that arise below this level require an external approach This is secured through an incision made just below and parallel to the lower border of the mandible, either anterior or posterior to the external maxillary artery, depending upon the point of localization An incision thus placed will leave a minimal scar, and its dependent position will facilitate escape of the pus by gravity

General measures directed toward strengthening of the patient's resistance and recuperative power are of prime consideration, especially in the case of infants, and include rest, proper nourishment, and prevention of dehydration Serotherapy, vaccine therapy, chemotherapy, and autotherapy have their advocates and opponents, but reports concerning the results of these measures are so contradictory that no conclusion can be reached as to their merits. The most beneficial effects are obtained from the use of repeated small blood transfusions on alternate days of 100 to 300 cc. of either

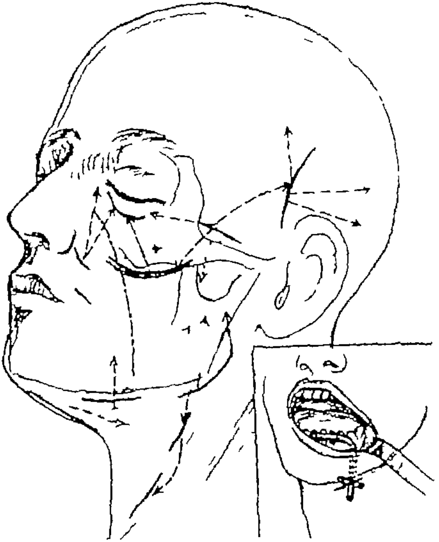


Fig 616 Incisions for drainage of soft tissues of face, to avoid damage to important subjacent structures. Dash arrows show direction in which forceps are introduced for drainage of superficial infections, dotted arrows, for deep infections (Ciesrynski) Insert shows through-and-through drainage in osteomyelitis of mandible. (Gordon)

whole blood citrated blood or the serum of an individual who has recently recovered from a staphylococcic infection The intravenous injection of a solution of 5 per cent dextrose and normal salt is a valuable adjunct. More recently, intravenous and intramuscular injections of prontosil combined with dextrose have been advised.

(2) **Removal of Dead Bone** No inflexible rule can be laid down in regard to the exact time at which the sequestrum is to be removed, since the time of separation will depend on the severity of the initial inflammatory process and the *stage at* which drainage was instituted. Premature removal may cause an interference with bone

regeneration and a resultant loss in continuity of the bone, distortion of the face, and malocclusion of the teeth On the other hand, too long a delay interferes with healing and may result in reabsorption of the newly formed bone The ideal time for removal is when the sequestrum has become loosened, and when an involucrum has formed strong enough to withstand the tension of the muscles and maintain the continuity of the bone Under ordinary circumstances, this process requires from 12 to 15 weeks after all signs of infection have ceased Roentgenographic examination is of inestimable value in determining the location of the sequestrum and its state of separation The necrosed portion will appear as a dark shadow and the involucrum as a lighter shadow surrounding it

Before any attempt is made to remove the dead bone, especially when located in the mandible or when there is doubt concerning the strength of the involucrum, the jaws are immobilized by splints or interdental wires, otherwise, "spontaneous" frac-

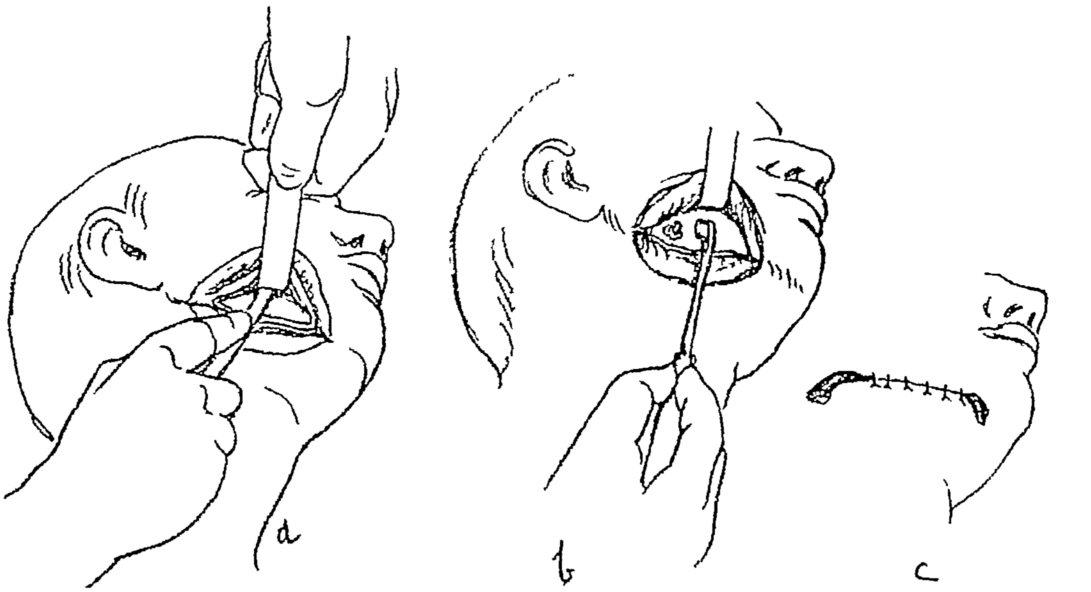


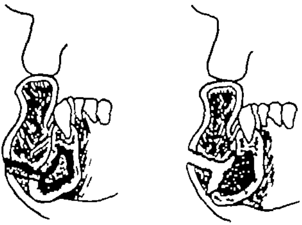
FIG 617 Removal of sequestra following osteomyelitis of mandible *a*, bone exposed through incision below lower border of mandible, to conceal scar Periosteum and soft tissue elevated en masse *b*, sequestra removed with curet, its cutting edge directed toward dead bone, to avoid injury to involucrum *c*, wound closed Drainage tube carried through both angles of wound

tures may occur and the remaining fragments be drawn toward each other by the contraction of the muscles, throwing the teeth out of occlusion and producing great deformity

The incision for sequestrectomy should be so planned as to leave a minimal deformity, permit of adequate exposure, and avoid injury to important structures In the case of children care must be taken to preserve the tooth buds, lest there be interference with the growth of the jaw If a sinus is present, its excision will provide convenient access to the sequestrum The incision is carried down to the periosteum, and the soft parts are retracted just sufficiently to lay bare the dead bone Too great retraction of the overlying tissues may encourage further necrosis and sequestra formation by cutting off the nutrition to the adjacent bone When the sequestrum has been thus exposed, a curet with its cutting edge directed toward the dead bone in order to avoid injury to the involucrum is slipped beneath it, and the fragment is carefully lifted out But if the involucrum is in the form of an overhanging wall and imprisons the seques-

trum, it may be necessary to nibble away a part of it with a rongeur before the necrosed portion can be extracted The granulations lining the cavity are scraped away, and the interior is searched for other fragments of dead bone which, if found, are removed Even small pieces of diseased bone, if allowed to remain, will act as foreign bodies and interfere with healing (figs. 617-618) If the defect is too large to be filled in with granulation tissue, it is saucerized by a trimming away of the overhanging edges, so that the surrounding soft tissue may fall in and obliterate it. Hemorrhage is controlled by the application of hot packs.

The remaining cavity is treated by a modified Orr technic It is washed with a 10 per cent solution of iodin and a 90 per cent solution of alcohol and plugged with vaselin gauze. This material is non-irritating causes no interference with the growth of granulations and exerts the required pressure to keep the wound open The parts are immobilized with interdental wires or splints (p 1207) The frequency of change of dressings is regulated by the amount and character of discharge from the wound. Oral cleanliness is maintained, and the patient fed as in the case of mandibular fractures (p 1215)



a b

FIG 618. Removal of sequestrum with overhanging involucrum. a, sectional view of mandible showing cloaca, sequestrum, granulation tissue, and overhanging involucrum. b fistulous canal excised overhanging walls of involucrum trimmed, and sequestrum removed. For details, see text. (Rowlands and Turner)

Because healing following sequestrectomy is a lengthy and tedious process various plans have been suggested to hasten it, but unfortunately they have for the most part failed to meet the expectations of their proponents. The use of bacteriophages is recommended by Albee (2), the bacteriophage being introduced into the cavity through a catheter fixed in a packing consisting of a 75 per cent paraffin and 25 per cent vaselin mixture. It seems questionable whether a bacteriophage can be of any benefit, inasmuch as it is eliminated within 24 to 48 hours and repeated inoculation produces an antiphage which destroys its function. Peptone broth has been used, on the assumption that it stimulates the reticulo-endothelial cells. A pack impregnated with a paste composed of 1 part glycerol and 2 parts magnesium sulphate has likewise been suggested, on the grounds that magnesium sulphate by its exosmotic action increases exudation from the wound (98) But magnesium sulphate, because of its high valence and active ionization retards phagocytosis and tends to dehydrate the granulation tissue The maggot treatment so popular in osteomyelitis of long bones finds little applicability in the

case of osteomyelitis of the facial bones, since, in addition to the general objections to this form of treatment (p 278), the profuse discharge and the extreme depth of the wound cavity cause the majority of the insects to die by drowning, and those which remain fail to act because of interference with their oxygen supply Recently, attempts have been made to develop a synthetic compound having the same therapeutic effects as maggots, calcium picrate, urea, and allantoin have been suggested for the purpose. Calcium picrate is employed as a suspension in the form of a 0 25 per cent aqueous solution of picric acid combined with 8 per cent glycerin and a suspension of calcium carbonate 20 grams in 215 cc of water (217) Urea is used in a 10 per cent aqueous solution, and allantoin in a 4 per cent solution (196)

(3) **Plastic Operations for Reconstruction of Residual Deformity.** The degree of functional disability and deformity following osteomyelitis of the facial bones is directly proportional to the size and location of the lost bone In the upper jaw even extensive necrosis results in comparatively little deformity, but in the mandible deformity is apt to be more pronounced, owing to the more extensive involucrum formation If the loss is slight, the gap will usually become obliterated by granulation tissue and require no treatment, but should it be considerable, plastic operations will be necessary to fill out the bone defect These must be delayed, however, until after the wound has become sterile, a process which requires a period varying from 6 months to a year

The cavity is filled either with a muscle flap or a bone or cartilage graft (fig 148) The procedure is best carried out in 2 stages, in the first sitting the scar in the soft tissue over the affected area is removed and the site of the future graft prepared, and at a second operation the transplant is introduced If the destructive process is limited to the teeth and the alveolus, it will be found more advantageous to replace these structures with a bridge or a denture, rather than subject the patient to a plastic operation. The details of reconstruction are given in Chapter XVII.

TUMORS AFFECTING FACIAL BONES

Tumors of the maxillofacial compound are divided for the sake of convenience into (1) those of extradental origin and (2) those of dental origin

Benign Tumors of Extradental Origin

Benign tumors of the bones of the face are relatively uncommon Owing to the preformation of the facial bones in membrane the great majority of tumors consist of fibrous tissue and bone In the *maxilla* ossification proceeds in membrane from three centers, one destined to form the maxilla proper, the second the prevomer, and the third the premaxilla During ossification there develops in the zygomatic region a cartilaginous mass which is either an accessory cartilage or the anterior end of the palato-pterygo-quadrate cartilage (68). This cartilage, however, plays no part in ossification (184) The *mandible* is also preformed in membrane with the exception of the part extending from the symphysis to the mental foramen, which is ossified in the anterior end of Meckel's cartilage (represented in the newborn as the spheno-mandibular ligament) and the condyle and angle, which are ossified from separate centers. Remains of these embryonic cartilages probably account for the occurrence of chondromata in this region

The benign tumors usually arise in the central portion of the upper or lower jaw and early in their growth present no subjective symptoms, frequently being discovered only by x ray examination for some other condition. They occur most commonly in young adults, are painless, single, of slow growth, and may cease to grow at any time. They have no tendency to become malignant and are easily diagnosed by roentgenographic examination. If small, they are best left alone, but if they have attained such proportions as to interfere with function or produce conspicuous deformity they should be excised. Since they are benign, this may be accomplished without the sacrifice of healthy bone.

As in the case of all tumors, a biopsy specimen should be obtained prior to operation. The growth is removed by raising a flap of soft tissue either intra-orally or extra-orally, depending upon the location of the growth, and chiseling the bone down to a normal contour

Osteomata (*osteofibromata, ossifying fibromata*) of the facial bones may be compact or cancellous, the latter type being the one most commonly encountered. Some are "composed of rather mature bone trabeculae with partly fibrosed marrow Others have islands of fibrous tissue undergoing varying degrees of ossification and calcification" (184) These growths may affect any of the facial bones, but the sites of predilection are the frontal process of the superior maxilla and the angle of the mandible.

Fibromata may originate in the fibrous tissue within the bone, or in the periosteum or endosteum, usually of the antrum. At first they are firm, dense, and slow in growth Later their vascularity is increased, and they develop more rapidly, often causing expansion of the bone and extensive deformities. They spread along lines of least resistance, frequently penetrating the oral or nasal cavity A roentgenogram reveals the tumor as a loose network of tissue surrounded by a thin shell of bone

Chondromata are small, encapsuled, lobulated growths composed of hyaline cartilage They occur at sites of embryonic cartilage rests, common localities being the symphysis and posterior part of the body of the mandible, the region of the inferior turbinates, and the cartilaginous septum of the nose. They run a course similar to that of fibromata, but because of their lobulated nature, complete removal is more difficult, and recurrences are therefore frequent.

Benign giant-cell tumors were first described by Nélaton (169), but to Bloodgood (31) must be given the credit for the definition of the condition as a pathologic entity Like all benign tumors, these growths occur most commonly in individuals between the ages of 20 and 30 (83) The definite cause is still a matter of conjecture. Some view the more destructive types as neoplastic in origin (219), others consider them to be a form of hemorrhagic osteomyelitis, the growth being nature's attempt to restore the lost bone (17), still others attribute their development to an imbalance in the process of repair resulting in an unusual increase in osteoclastic proliferation and a diminution of new bone regeneration (83) Finally, there are some who look upon them as a phase of osteitis fibrosa cystica occasioned by a disturbance of calcium and phosphorus metabolism due to a hyperparathyroidism (p 1010)

These tumors are found in the mandible and in the alveolar process of the maxilla. They originate in the interior of the bone and tend to expand the cortical plate. The growth appears as a compact mass studded with numerous small cystic areas. The solid parts are composed of friable granular material varying in color from yellow to red, and on section they have the appearance of freshly cut liver or "an old bruise"

(33) While the growth is encapsuled, it not infrequently perforates the membrane Under the microscope the tumor shows large multinuclear cells in an exceedingly vascular stroma of round, spindle, and polygonal cells Hemorrhagic areas are common, and around these areas giant-cells predominate The origin of the latter cells is unknown, but according to Mallory (153), they are similar to osteoclasts of normal bone and result from the fusion of endothelial cells attracted to the tumor by the presence of lime salts, fatty acids, and cholesterin crystals Other investigators view them as abortive vascular sprouts (145)

Pain is not a prominent symptom and is often absent until the tumor has attained considerable size However, palpation may elicit slight tenderness The deformity is pronounced and manifests itself as a smoothly rounded mass If it perforates the

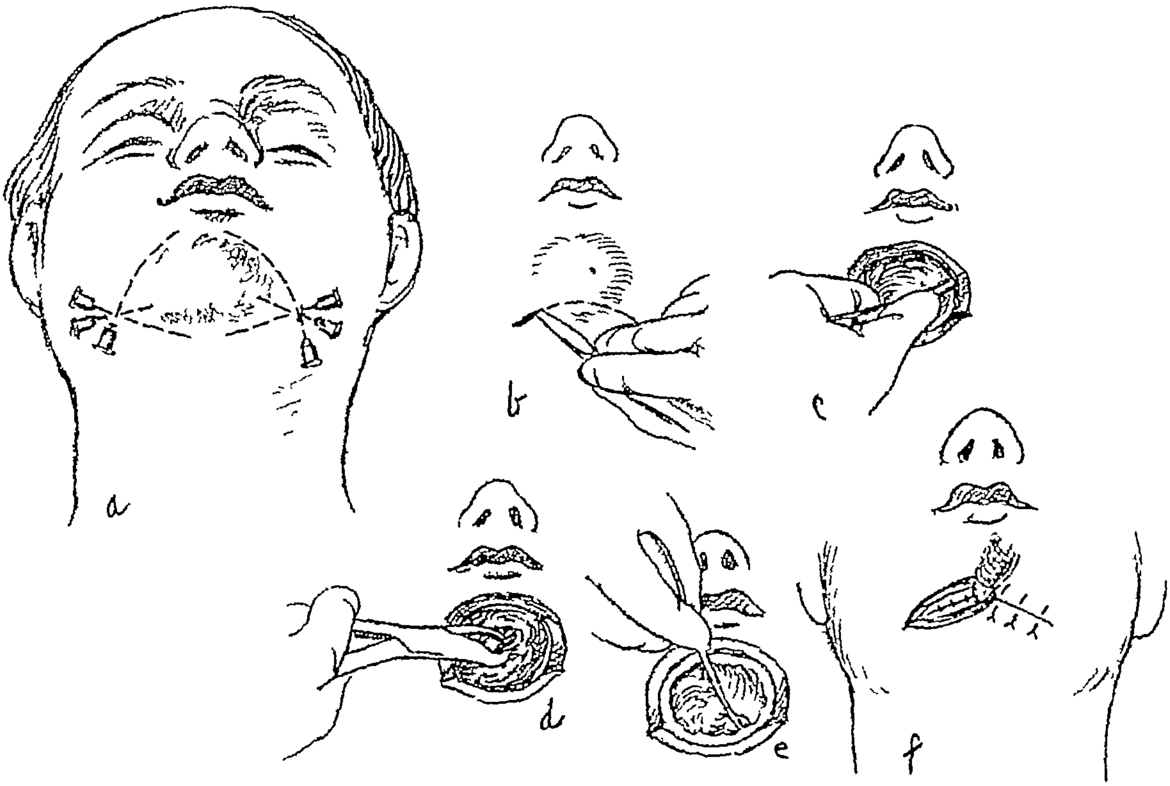


FIG 619 Removal of giant-cell tumor of mandible *a*, operative field anesthetized by circular block *b*, incision made beneath mandible down to bone *c*, soft tissue and periosteum elevated *d*, outer bony shell removed with forceps *e*, tumor tissue curetted away *f*, wound closed, with dependent drainage

bone, the overlying mucous membrane assumes a characteristic dark red color Because of the thinning of the bone, the part often responds to the touch with an egg-shell crackling Roentgenographic examination reveals the growth as an ovoid shadow with incomplete trabeculation at its margin and surrounded by a clearly defined expanded bone without periosteal involvement A growth of this kind, if left untreated, may reach great proportions and in time become infected or give rise to "spontaneous fractures"

Before a diagnosis can be made, the microscopic, [illegible]ical, and x-ray findings must be correlated Dentigerous cysts may be distingu[illegible] their association with non-erupted teeth, and by th[illegible] ularity and a[illegible] trabeculation Radicular cysts occur in the uppe[illegible] or region an[illegible] in relation with non-vital teeth Adamantine ne[illegible] recognized [illegible] clearly defined trabec-

ulation, slower growth and microscopically, by the typical adamantine epithelium. Osteogenetic sarcomata are characterized by a periosteal reaction and more rapid growth

Inasmuch as giant-cell tumors are essentially benign, the *treatment* is conservative. The radical operations of the past with their crippling and disfiguring results have been abandoned The tumor may be destroyed either by curettage followed by cauterization (30) or by irradiation (31, 183, 213) Eradication by the latter method, however is not only a long-drawn, tedious procedure, but it does not offer the advantages of biopsy—a really serious objection, since the condition cannot always be definitely differentiated from malignancy without the aid of such an examination Probably the most satisfactory effects are obtained from a combination of curettage and irradiation. The tumor is exposed through an intra or extra-oral incision, depending upon its location, and the mass is completely extirpated, care being taken not to destroy the continuity of the bone (fig 619) The walls are then electrothermically desiccated or cauterized with pure phenol or iodin and the cavity is allowed to heal by granulation X ray therapy is instituted postoperatively If the bone has been destroyed, it may be necessary to resect a portion of the jaw For details of the technic, see page 1002

Malignant Tumors of Extradental Origin

Malignant tumors of the facial bones, while more common than benign, comprise only 1 per cent of all malignant growths. The etiology of such growths, like that of malignancies in other parts of the body, is still obscure. Statistics show that they are more common in males, in the ratio of 2 to 1, and that they occur, as a rule, at about middle life As elsewhere, they appear in the form of either a sarcoma or a carcinoma, but a histologic classification presents considerable difficulty, since within a single tumor cells may be encountered of both a sarcomatous and a carcinomatous nature

Sarcomata may involve either jaw but more often attack the mandible In the upper jaw the maxillary sinus is the most common site. Metastases take place through the blood stream and are most frequently encountered in the lung Of the sarcomata, Hellner distinguishes (1) osteogenetic sarcoma arising in bone forming germinal tissue In the facial bones these growths do not differ from similar tumors in other bones. They may be of the spindle or round-cell variety and originate most frequently beneath the mucoperiosteum on the anterior or posterior wall of the maxillary sinus, or on the external surface of the bone. In either case they spread rapidly (2) Ewing's sarcoma which presents a picture of alveolar sarcoma. (3) Unclassified mixed types which contain fibromatous chondromatous, and myxomatous tissue As elsewhere in the body, the malignancy is measured by the degree to which the cells fail to become differentiated from those of the structure in which they arise. Thus, these tumors are less malignant than are the osteogenetic type, although they may grow to a great size and cause extensive deformity

Carcinoma of the maxillofacial compound is usually an extension of carcinoma from the cheek, floor of the mouth nose, or mucous membrane of the antrum and tonsils. In rare instances it is primary, beginning as an adamantine carcinoma In the face the growth is either of the squamous cell or the columnar cell type. The prognosis of the latter form is less favorable owing to its greater radioresistance.

The symptoms and prognosis of malignant tumors of the face are determined to a large extent by their location In order to facilitate their study, an imaginary line may be drawn from the inner canthus to the angle of the mandible on either side, both halves of the countenance being thus divided into an upper posterior and a lower anterior region (175) Tumors in the *upper posterior region* are more serious, because their anatomic position makes them less accessible to operative attack and permits of a more rapid extension of the malignant process to the meninges and vascular trunks Those in the *lower anterior section* offer a better prognosis, since they are more easily approached and may grow to considerable proportions before invading structures that would make their removal impossible

The upper posterior and lower anterior divisions may in turn be subdivided into a medial and a lateral section. Tumors arising in the *upper medial division* usually spring from the ethmoid and spread to the pterygoid plate, the retromandibular lymphatic glands, and the lateral wall of the nasal fossa These are the most alarming of all facial tumors, since their proximity to the cranial cavity permits of an early invasion of the meninges At the beginning the condition may manifest itself merely by an intermittent epistaxis, a nasal discharge, and unilateral nasal obstruction (33) A definite diagnosis (32) can be made only by roentgenographic examination, exploration of the antrum, and biopsy To prevent a possible dissemination of the tumor, the specimen is removed by electro-surgery with a cutting current. This closes the blood and lymphatic channels and kills the tumor cells on the surface If the malignant process spreads to the orbit, the lids become swollen, movement of the eyeball is restricted, and frequently there results exophthalmos and compression of the optic nerve If the growth begins in the nasopharynx, the upper jaw is forced forward, the zygoma becomes thinned and flattened, and there is early pain, epiphora, dyspnea, and epistaxis

Tumors arising in the *upper lateral division* encroach upon the posterolateral region of the antrum, the temporal and pterygomaxillary fossa, and the lateral part of the orbit Obviously, these growths are more accessible to treatment than are the previously mentioned group Here pain is evident along the distribution of the second division of the fifth cranial nerve, and the eye is displaced upward and toward the median line

In the *lower medial region* the growth involves the alveolar process, the hard palate, the anterior and lower part of the antrum, and the lateral wall and floor of the nose. Tumors in this region offer a comparatively favorable prognosis They are evidenced by a destruction of the alveolar process, loosening of the teeth, and local abscesses Palpation reveals a thickening of the bone and the presence of small nodules beneath the mucous membrane. The mass may perforate the palate into the mouth or obstruct the nasal cavity Hemorrhage and pain occur at a late stage, and foul discharges are absent until the growth begins to disintegrate If the growth is situated in the maxillary sinus, the cheek becomes swollen, and x-ray examinations in several different planes will show the walls of the orbital, nasal, facial, and zygomatic cavities expanded, the palate depressed, and the alveolar border displaced Transillumination will reveal opacities

Tumors in the *lower lateral region* involve the posterior part of the alveolus and hard palate and soon encroach on the ascending ramus of the mandible, causing trismus and pain from involvement of the inferior dental nerve The retromandibular glands, tonsils, and faucial pillars are promptly invaded, and as a result deglutition is rendered

difficult. Pressure on the eustachian tube causes pain and deafness. Hemorrhage comes on late being due to erosion of the branches of the external carotid artery and is always serious.

Generally speaking, the malignant tumors which offer the best prognosis are those which are hard in consistency, well defined, of slow growth and limited to the bones. The unfavorable cases are the rapidly growing, soft, vascular, ill-defined tumors involving the integument and giving evidence of extension into the orbit and nasopharynx.

Management

The most promising method of treatment for malignancies of the facial bones consists in the removal of the tumor by endothermy preceded and followed by radiotherapy While endothermy prolongs the process of healing, increases the tendency toward late hemorrhage and augments the technical difficulties of operation, it is preferable to the use of knife and scissors in that it diminishes shock, causes less mutilation, reduces the incidence of recurrence, and lowers the mortality

Preparation for Operation. Prior to operation the general condition of the patient is brought to an optimum, and the aseptic measures common to all intra-oral operations are carried out. All infected and carious teeth are extracted, diseased tonsils attended to, and the mouth asepticized by frequent cleansing with some mild antiseptic solution If a prosthesis is to be applied after the operation to prevent distortion of the soft tissues by contraction or to maintain the continuity of the bone, it is constructed in advance, so that there may be no delay in its application

Three or 4 days prior to operation radiotherapy is administered to lower the vitality of the tumor cells and bring about a regression of the growth. Ohngren (175) administers high-voltage x rays "with a screen equivalent to 2 6 mm copper in daily doses of ½ to ⅓ H.E.D to different fields in turn. These fields were selected so as to obtain a 'cross-fire against the area affected by the tumor The total dose to the skin has generally amounted to 1 H.E.D on each field. Since 1929 the teleradium apparatus containing 3 grm. of radium has been used to irradiate the tumours from six or seven different ports, and the total amount given has varied between 30,000 and 70,000 mgm. hrs. The distance from the radium containers to the skin was 6 cm and the total filtration was equivalent to 6 mm of lead When doses up to 70,000 mgm. hrs. were given, a lively reaction of the skin followed. This epidermitis does not usually last more than four or five weeks, and no endothermy operations have been performed until such reactions had passed.'

Anesthesia. Malignant tumors may be removed under general or local anesthesia. If a general anesthetic is to be employed, it is induced by the endotracheal method, as this permits of the packing off of the pharynx with gauze, thus preventing the aspiration of blood into the lungs and promoting free respiration despite the collection of fluid in the pharynx If a local anesthetic is to be used, nerve blocking is resorted to, supplemented by infiltration of the operative field with a solution of 2 per cent procain epinephrin.

To anesthetize the *upper jaw* the second division of the trigeminal nerve is blocked at the foramen rotundum, which is reached either by way of the pterygopalatine fossa or through the orbit. If the former approach is chosen, the needle is inserted at the zygomatic tubercle on the lower border of the zygoma and directed upward and inward

destruction by means of electro-coagulation and have removed the bone up to the cribriform plate In the cribriform plate the development of heat must be carefully controlled and it is necessary to use a number of electrodes of unequal size—such as needles, plates, and balls—if damage is to be avoided

"In evacuating ethmoidal tumours, we cook the mucous membrane in the nasopharynx and sphenoidal sinus, for although it presents a normal appearance to the eye, the microscope frequently shows that it contains incipient tumour deposits"

Out of 175 cases of malignant maxillofacial tumors treated by electrosurgery and irradiation in Ohngren's clinic, the operative mortality was 11 4 per cent, 41 7 per cent were free from recurrence for the space of 1 year, 34 2 per cent for 2 years, 30 8 per cent for 3 years, and 30 8 per cent for 5 years In Pichler's (185) series the mortality within 2 months was 11 per cent, 21 6 per cent were free from recurrence after 1 to 2 years; 20 per cent after 2 to 3 years, 16 per cent after 3 to 4 years, 14 per cent after 4 to 5 years, 13 per cent after 5 to 10 years, and 5 per cent after 10 to 16 years Among

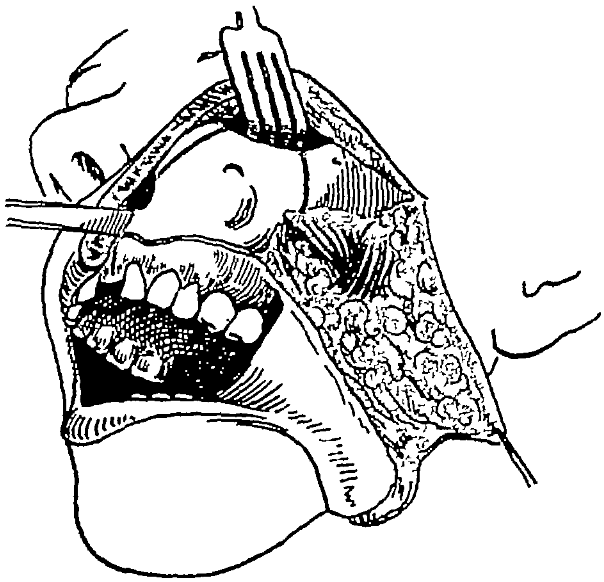


FIG 620 Exposure of maxillary tumor Soft tissues of cheek retracted Oral mucosa incised along upper fornix. Solid lines indicate incisions for resection of bone. For details, see text

118 cases similarly treated by New and Cabot (172) 44 9 per cent 5-year cures were reported

Resection. In view of the fact that endothermy combined with preoperative and postoperative irradiation offers a more favorable prognosis, entails less mutilation, and results in fewer recurrences than complete resection of the jaw, the latter method has been generally abandoned Nevertheless, the old classical operation of complete excision will be described, as it forms the basis of the various operations of *partial resection* which are occasionally employed to advantage in combination with endothermy

Resection of Maxilla (fig 620) The bone is exposed through the external incision described on page 998 The upper jaw has four bony articulations which must be severed before it can be removed—an upper lateral directed toward the zygoma, an upper medial toward the nasal bone, a lower medial toward the reciprocal palate and upper jaw, and a lower lateral toward the sphenoid bone and palate The separation is begun at the zygomatic articulation, thus: The periosteum is separated from the

floor of the orbit as far back as the sphenomaxillary fissure. With the orbital contents protected by means of a spatula, the masseter muscle is separated from the bone. The bone is then divided with a stout saw, a bone-cutting forceps, a gigli saw, or a chisel. The section is usually made at the level of the outer third of the orbit. If a gigli saw is employed, a curved aneurysm needle is introduced through the infra-orbital fissure and made to appear below the lower border of the zygoma. A silk thread is attached to the eye of the needle and used as a pilot to draw the saw into position. After the instrument is in place, the bone is severed. If the zygoma has been invaded by the tumor, the osteotomy is made through the zygomatic process of the temporal bone.

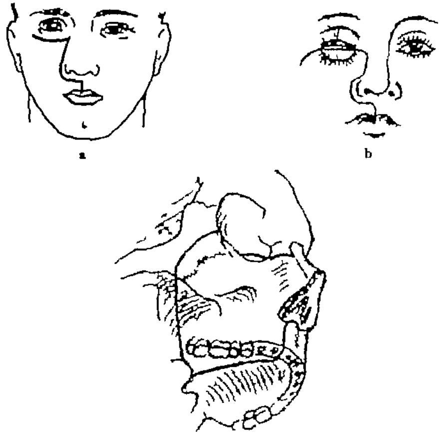


FIG. 621. Resection of maxilla. *a*, classic incision for exposure of bone. (Fergusson.) *b*, Trotter's incision. *c*, lines of incision for bone resection. For details, see text.

The upper medial articulation is then separated along the frontal process of the superior maxilla. With a stout saw a groove is first made through the outer plate, the instrument passing obliquely just above and medial to the infra-orbital foramen. Then with one blade of the bone forceps placed inside the nasal fossa and the other within the orbit, the bone is cut through. If a gigli saw is to be used for the purpose, it is passed into the pyriform opening and made to emerge through the orbital cavity.

The lower medial articulation next demands attention. The mouth is widely opened and if no empty sockets already exist, a central or lateral incisor tooth is extracted. An incision is then made beginning posteriorly at the junction of the hard and soft palates and extending along the midline of the hard palate to the teeth and thence along the anterior aspect of the alveolus into the nostril. Another incision starting at the posterior extremity of the first, is carried outward along the junction of the hard

and soft palates toward the molar teeth on the affected side The soft palate thus freed is detached from the hard palate with a scalpel A groove is then made in the hard palate with a saw admitted through the nose opposite the tooth which has been extracted A long bone-forceps is introduced, one blade being placed in the nose and the other in the mouth, and the bone is divided If a gigli saw is to be used, a catheter is first passed into the pyriform opening and made to appear intra-orally between the hard and soft palates With the catheter acting as a guide, the saw is drawn through, and the bone is divided

Finally, the soft parts are retracted widely as far as the tuberosity of the maxilla, and the last articulation, the lower lateral, is separated with a chisel and mallet The bone thus freed should be lifted out as rapidly as possible, since the internal maxillary artery is bound to be ruptured in the process, and bleeding cannot be controlled until the bone is completely removed The maxilla is grasped with a forceps, one blade resting on the hard palate and the other on the anterior aspect of the bone, and with a rocking movement it is freed, any remaining soft tissue attachments being torn away Hemorrhage, which is invariably profuse, is checked by the introduction into the cavity of a large tampon wrung out of hot saline solution After a few minutes the plug is withdrawn, and all bleeding vessels are ligated

If it is at all possible, the orbital plate should be preserved, otherwise, the eyeball with its periorbital tissue loses anchorage and sinks, with resultant deformity, severe disturbance of vision, edema, paralysis of the orbicularis oculi, and epiphora Should destruction of the plate be unavoidable, a useful plastic operation which will do much to correct the disfigurement and prevent visual impairment may be carried out at the time of operation The details are as follows The cheek flap is folded back until the anterior portion of the temporal muscle is exposed as far as its insertion into the coronoid process A section of the muscle 2 to 3 cm in width is detached down to its point of insertion, and the flap of muscle is lengthened by the separation of a long narrow section of bone from the coronoid process This flap, consisting of muscle and bone, is swung horizontally beneath the orbit and fixed to the remaining portions of the frontal process of the upper jaw, so that a new orbital floor is created

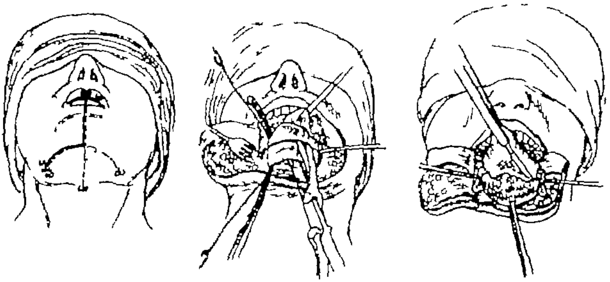
Before the conclusion of the operation the residual cavity is carefully inspected for any evidence of infiltrated tissue, and all suspicious areas are excised or treated by endothermy A previously prepared prosthesis is then introduced, which not only serves to anchor the tampon, but also prevents distortion of the soft parts by cicatricial contraction during the process of healing Finally, the soft tissue flap is replaced, and the margins are united by interrupted silk sutures The wound is dressed in the usual manner

Resection of Mandible If the tumor is limited to the alveolar process, it may be excised through an intra-oral incision and without destruction of the continuity of the arch With the lip drawn down, the soft tissues around the growth are incised and reflected back to expose the bone The tumor is outlined by a series of drill holes made well into healthy surrounding bone By means of a chisel these holes are connected, and the growth thus freed is removed

If the tumor is near the angle of the mandible, adequate exposure cannot be obtained intra-orally, and therefore an external incision must be resorted to The lip is divided in the midline and the incision extended below and parallel to the lower jaw in the direction of the mastoid process (fig 622-a) This has supplanted the former horizontal in-

cision across the cheek, since it provides an adequate exposure and the resultant cicatrix is less conspicuous. Lexer (138) believes that division of the lip is unnecessary and exposes the tumor through an incision entirely below the mandible

In the case of more extensive involvement the continuity of the arch must be destroyed. The incision for exposure will depend upon the extent of infiltration. If only bone requires removal, access to the tumor may be obtained either through an incision which begins at the middle of the lower lip and runs vertically downward to the hyoid bone, or through a horizontal incision made below and parallel to the mandible and extending between its angles. Should a more elaborate dissection be necessary, the 2 last mentioned incisions may be combined and the 4 flaps thus outlined retracted to furnish the necessary exposure. Occasionally, adequate exposure can be secured through von Langenbeck's incision, whereby the lip is divided down to the lower border of the mandible and the incision extended along its lower margin to the angle (fig 622-a)



a b c

FIG 622. Resection of symphysis. *a*, incisions of approach. *1–1* Kocher's incision. *2–2* Lexer's incision. *3–3* Sédillot's incision. *4–4* von Langenbeck's incision. *b* soft tissues retracted. Mandible fixed with bone forceps and cut through with gigli saw *c* bone turned down and separated from soft tissue along dotted line. For details, see text.

Irrespective of the method of approach, the mucous membrane is incised along the lower fornix and the soft tissues are separated from the outer surface of the bone and retracted. The inner surface of the bone is then bared, the dissection being carried from below upward The submental and submaxillary lymph-nodes are carefully dissected out on both sides. With the tongue controlled by means of a traction suture, drill holes are made into the healthy bone on either side of the growth and connected by chiseling the bone between them. The resection may also be made with a motor driven saw or a gigli saw If the latter instrument is used, the bone is held firmly in a bone forceps and a grooved director is passed from the lower border of the jaw through the floor of the mouth into the buccal cavity as a protection to the soft tissues and a guide for the saw The saw is then passed into the groove of the director, the handles are affixed and the mandible is cut through (fig 622 b) The same procedure is repeated on the other side The bone section, which now remains connected only to the soft tissues on the floor of the mouth, is freed and removed. The cut margins

of mucous membrane, together with the muscles on the floor of the mouth, are approximated by means of silk sutures, and a prosthesis previously prepared is inserted Finally, the mucosa of the mandible and the overlying soft parts are sutured back in place, and a drainage tube is inserted into the most dependent part of the wound

The technic for a *complete unilateral resection of the mandible* is as follows. With the patient's head and shoulders raised and the head rotated to expose the affected side, a vertical incision is made, bisecting the lower lip and chin down to the symphysis, continuing thence in an archlike manner to the hyoid bone, and from there passing backward and upward to the mastoid process The external maxillary artery is freed and divided between two ligatures The flap of soft tissue and muscle thus outlined is raised Should the muscles as well as the bone be infiltrated, the flap is made to contain only skin, subcutaneous tissue, and platysma The superficial layer of deep cervical fascia is divided just above the hyoid, and the superficial cervical lymph-glands are removed If the deep cervical glands are involved, they are excised after the stylohyoid and the posterior belly of the digastric muscles have been cut through at the level of the hyoid bone The internal jugular vein is exposed, in order that the lymph-glands may be removed at the carotid bifurcation After these glands have been resected, the remaining soft tissues are detached from the outer surface of the jaw The inner aspect of the mandible is bared by the division of the mylohyoid, digastric, geniohyoglossus, and geniohyoid muscles anteriorly and the internal pterygoid posteriorly A grooved director is passed beneath the bone just lateral to the symphysis A gigli saw is then introduced, and the bone is severed, enough periosteum being left in place to cover the cut surface of the bone Should it be necessary to remove the symphysis with its attached lingual muscles, the tongue is prevented from falling back into the pharynx by a suture passed through its substance After the bone has been severed, the jaw, held in a bone-forceps, is everted, and the remaining mucosal attachment is severed, care being taken to preserve as much of the membrane as possible The internal pterygoid muscle is divided and the inferior dental vessels ligated The jaw is then depressed, so that the temporal muscle may be lowered and its separation facilitated. In some cases it may be necessary to excise the coronoid process before the muscle can be freed After the tendon of the temporal muscle has been cut, the mandible is further depressed until the condyle is brought into the field of operation In the course of these manoeuvers rotation of the bone should be avoided, as this is apt to cause a rupture of the internal maxillary artery The capsular ligament is opened in front, and the external pterygoid is divided With the knife or scissors kept close to the bone, the remaining ligaments are cut, and the jaw section is removed. Hemorrhage is then controlled, and a prosthesis is introduced The soft tissues are replaced and the margins coapted, care being taken that the red line of the lip is accurately united and that the mucous membrane of the lip is sutured to that of the cheek Finally, a drainage tube is introduced, and the wound is dressed in the usual manner

Postoperative Care. Immediately following the operation there are distributed in various parts of the operative wound 4 tubes containing 25 mg of radium element in a capsule of aluminum and platinum equivalent to 1 or 2 mm of lead, with an extra screen equivalent to 2 mm of lead The total dosage ranges between 500 and 2000 mg hours Despite the disadvantages of the application of radium at this stage—viz , the possibility of osteonecrosis, retardation of the healing process, and the pre-

disposition to pulmonary and cerebral complications—it should not be omitted, since its prophylactic effect outweighs these objectionable features.

During the postoperative period the patient is kept in a semiupright position to promote the escape of the discharges He is encouraged to wash the mouth frequently with some antiseptic solution, especially after meals. As soon as his condition permits small doses of x ray or teleradium are given in 2 or 3 series at intervals of 3 months. In case of suspicious enlargement of the regional lymphatic glands, the treatment is mainly directed to the neck (175)

Tumors of Dental Origin

Owing to the many conflicting opinions regarding the pathogenesis of tumors of dental origin a great deal of confusion exists in their classification Some are ectodermic and constitute true tumors, whereas others are merely irregular masses of calcified dental tissue which do not increase in size and fail to show clinical or histologic characteristics of true neoplasms. The customary grouping into "solid" and "cystic" tumors is impractical, inasmuch as both solid and cystic masses may exist in the same growth For want of a more satisfactory classification therefore, these growths will be described in the following order

Dentigerous Cysts (Follicular Cysts, Odontoceles)

Dentigerous cysts are benign embryonic growths into which project one or more imperfectly formed or aberrant teeth They become manifest at the period of eruption of the permanent teeth the most common sites being the mandibular canine and the third molar regions. Their formation has been explained on the assumption that the outer layer of cells of the enamel organ instead of adhering to the enamel of the tooth as Nasmyth s membrane, becomes separated from it to produce the epithelial lining of the cyst capsule The mucoid fluid within the cyst cavity is believed to result from degeneration of the stellate reticulum (107) Another theory is that delayed eruption is the responsible factor the tooth becoming surrounded with an area of fibrosis in which cystic changes take place (151)

Anatomically the growth consists of a fibrous capsule lined with squamous epithelium and filled with a straw-colored mucoid fluid Into the cyst cavity projects the crown of an unerupted tooth The growth manifests itself as a gradual painless enlargement of the jaw, affecting principally the outer plate of the alveolus, it may grow for years and attain considerable proportions before creating any discomfort. As it increases in size it produces a convexity on the buccal wall, distending and attenuating the bone. Frequently the bone becomes so thin that palpation elicits an egg shell crackling and through the mucous membrane the bluish mass of the cyst can be seen. The absence of a tooth is an important clinical sign in this type of dental tumor Recurrent inflammation and suppuration are common sequelae. X ray examination reveals a deformed or displaced non-erupted tooth lying within a cystic cavity

The *treatment* consists in the extraction of the unerupted tooth and the complete removal of the cyst with its capsule The overlying gum is dissected back in the form of a flap, and the thin bone is exposed and removed with a rongeur By degrees the cyst capsule is separated from its bony wall, and after its complete excision the remaining cavity is packed and allowed to heal from below upward (fig 623)

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Radicular Cysts (Dentoperiosteal Cysts, Dental Root Cysts)

Radicular cysts are of frequent occurrence and usually appear as a result of inflammation, necrosis, or destruction of the pulp at the apex of a tooth They are most common in adults and are as a rule found at the roots of teeth in which the pulp is diseased or absent Their exact origin is unknown It has been suggested that they may arise from supernumerary embryonic centers (172) Another theory is that they develop in the depth of the dental pulp or in a pulp-chamber as an infection of low virulence which stimulates the peridental débris to cyst formation (54) Moorehead and Dewey (166), in summarizing the possible etiology of these cysts, write "We may say remnants of Hertwig's epithelial root sheath or Malassez's peridental epithelial débris are probably the most frequent, but not the only source of derivation Remains

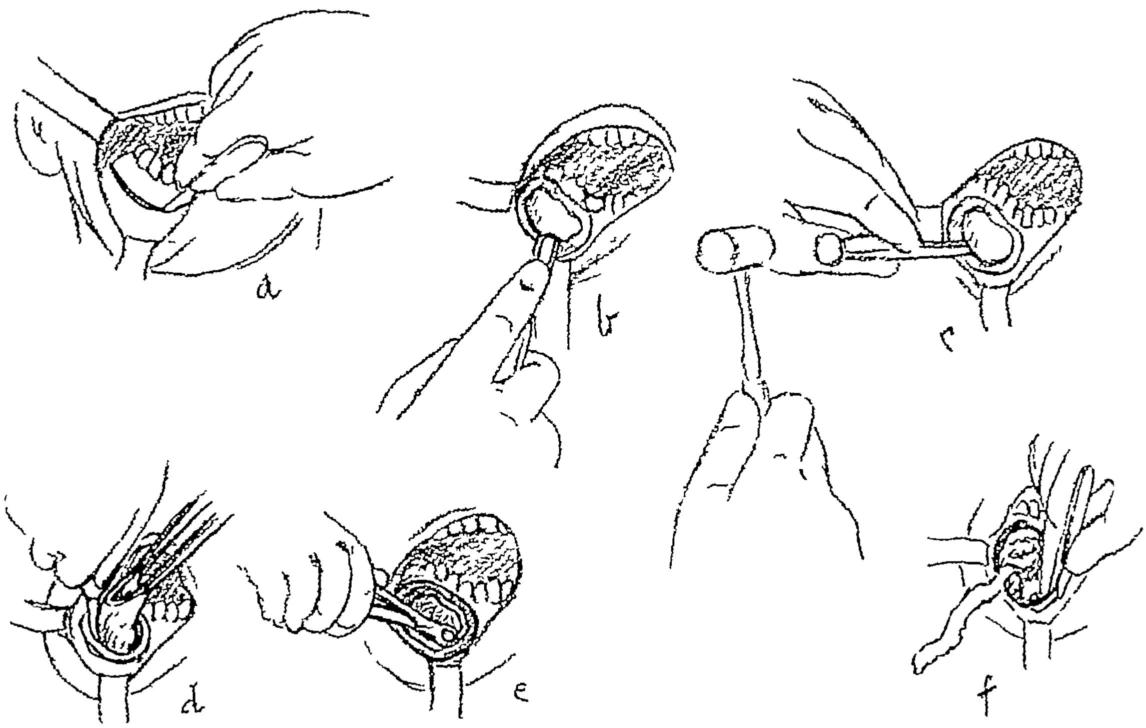

FIG 623 Removal of cyst from mandible *a*, lip retracted, and horizontal incision made in mucosa *b*, overlying soft tissue separated *c*, anterior bony wall of cyst removed with chisel and mallet *d*, cyst wall, held in forceps, separated from its bed with dull elevator and removed *e*, margins of bony cavity rounded off with rongeur *f*, bone cavity packed

of the epithelial budding from various parts of the tooth gum and the gingiva, such as described by Malassez, must also be taken into consideration, and finally the proliferation of the adult oral epithelium may be the origin of the cyst epithelium in some cases "

These cysts may be unilocular or multilocular and range in size from a pea to a walnut If they are large, they appear as smooth, globular, painless masses They are more common in the upper jaw than in the lower in the proportion of 3 to 1, and are usually situated in the region of either the second incisor or of the bicuspid In the mandible the most frequent sites are the bicuspid and molar areas The rate of growth is slow, extending over a period of years As they develop, these cysts devitalize the adjoining teeth and, in the maxilla, may encroach upon the maxillary sinus or nasal fossa On section they are found to be composed of a fibrous tissue capsule

lined with multiple layers of squamous epithelium. Their contents range from an amber-colored fluid to a semisolid substance which in case of infection is converted into pus. X ray examination reveals a clearly defined area with sharply demarcated margins in relation with the apex of a pulpless tooth.

Before the cyst is removed, the teeth responsible for its growth must be extracted. The method to be employed for the excision of the cyst itself will depend upon its size, the condition of the mucous membrane, and the presence or absence of infection.

In the case of small cysts which do not exceed 15 mm. in diameter and which are not infected the most satisfactory treatment is complete extirpation, as follows A flap of gingival tissue is raised directly above the cyst and retracted to expose the growth.

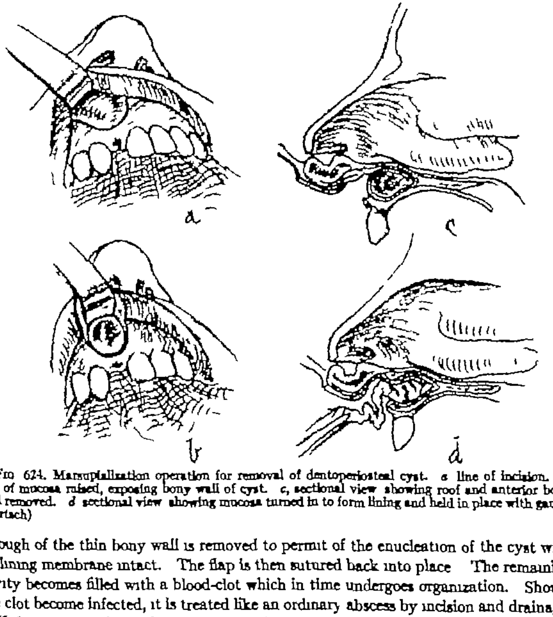

FIG 624. Marsupialization operation for removal of dentoperiosteal cyst. *a* line of incision. *b* flap of mucosa raised, exposing bony wall of cyst. *c*, sectional view showing roof and anterior bony wall removed. *d* sectional view showing mucosa turned in to form lining and held in place with gauze (Partsch)

Enough of the thin bony wall is removed to permit of the enucleation of the cyst with its lining membrane intact. The flap is then sutured back into place The remaining cavity becomes filled with a blood-clot which in time undergoes organization. Should the clot become infected, it is treated like an ordinary abscess by incision and drainage.

If the cyst is so large that removal of the overlying bone would cause extensive deformity or injury to important structures, such as the inferior dental nerve, or would necessitate an incision into the maxillary sinus or nasal cavity Partsch's (177) marsupialization operation is the one of choice. The details are as follows (fig 624) A flap of gingival tissue is raised, and the roof and anterior wall of the underlying cyst are removed, the posterior wall being left intact, the cyst and mouth thus forming one

continuous cavity The gingival flap is then turned into the cyst cavity in such a manner as to provide it with a new lining and is made to adhere by means of a gauze pack which is left in place for 4 or 5 days After healing is complete, the cyst cavity will remain as a large depression opening into the mouth

Adamantinomata (Ameloblastomata)

These are solid or cystic dental tumors occurring most often in women between the ages of 20 and 30 They are relatively uncommon and of a low degree of malignancy, having a tendency to recur after incomplete removal Their exact origin is still a subject of considerable speculation, and it is debatable whether they should be grouped with the epithelial variety of odontomata or given a separate classification as epithelial tumors of the gums The most widely accepted opinion is that they arise from the more mature embryonal rests of the adamantine epithelium of Malassez (152) and are activated to proliferation by trauma (66)

These tumors are surrounded by a fibrous capsule which adheres to the bone In time they may perforate the outer cortical plate and invade the soft tissues The solid type is comparatively rare and is almost exclusively confined to the maxilla, it is more likely to become malignant than the cystic variety Microscopically, they are composed of anastomosing strands of epithelium which tend to undergo degeneration and liquefaction, forming cavities filled with fluid Cystic adamantinomata usually affect the angle of the mandible and may either be cystic from the beginning, or may represent a cystic degeneration of the solid variety, in which event some of the spaces are cystic, while others are filled with compact material The bulk of the growth consists of trabeculae of fibrous tissue or bone which divide it into numerous compartments filled with a brownish fluid

Diagnosis can be made by a history of trauma, such as the extraction of a tooth, followed by an intermittent sinal discharge lasting over a period of months or years, and a progressive painless swelling in the molar region As the mass continues to increase in size, it may project into the oral cavity and interfere with mastication and speech If left untreated, the growth may become infected and present symptoms simulating those of osteomyelitis Palpation discloses a lobulated surface, and pressure reveals a certain elasticity caused by the thinning of the wall An x-ray examination reveals a trabeculated mass

The choice of treatment will depend upon the nature of the growth and its stage of development Early in the process, while the tumor is still small and surrounded by well-defined bony walls, it is possible to effect a cure by enucleation followed by curettage and thus avoid resection with its danger of a solution in the continuity of the bone Some surgeons, however, advocate resection in all cases to insure against recurrence (203, 212)

When the tumor is large and has perforated the cortical plate and entered the soft tissue, complete resection will be necessary (p 1000) In such cases a prosthesis designed to retain the fragments in their normal relationships during the period of healing is constructed before the operation and is worn for several months postoperatively, until the defect can be reconstructed with a bone graft Since these growths show a propensity to recurrence, it is important that every particle of the abnormal epithelium be removed, and that their surgical removal be supplemented by the administration of x-ray or radium (185)

Odontomata

The term "odontoma" was coined by Broca (37) in 1869 and is used to designate an irregular mass of malformed dental elements containing a part or all of the constituents of a developing tooth These growths usually appear before the twenty fifth year and are found principally in the molar region of the lower jaw They are classified into a radicular type composed of root elements only, and a composite variety, consisting of dentine, cementum, and enamel. The former, derived from the dentine and cementum alone, are mesoblastic in origin, while the latter, incorporating enamel elements, are epiblastic.

Odontomata often escape notice until they have reached considerable size or show evidence of infection. Inasmuch as they most frequently develop in place of the first and second molar teeth, the reason for the absence of these teeth should be ascertained when an odontoma is suspected. When the growths are encountered in the presence of a full complement of teeth, the cause is attributed to the existence of supernumerary follicles. The tumor appears as an irregular mass containing varying proportions of dentine, cementum, enamel, and pulp canals. Occasionally, a fully formed tooth is found embedded in the mass

Since these growths frequently become infected and undergo suppuration, they should be excised. Their removal occasions no serious difficulty The overlying gum is incised, and the mass is removed in the same manner as an impacted tooth, some of the bony covering being chiseled away As they are always benign, no more of the jaw should be sacrificed than is necessary for their extirpation.

Miscellaneous Group of Conditions Resembling Tumors

Epulis

Epulis is a term loosely applied to circumscribed proliferative masses situated about the alveolar ridges at the gingival margins of the teeth. The name was coined by Virchow (228) and has since been made to include various conditions ranging from gingival hypertrophies due to inflammation and infectious granulomata to true neoplasms of a fibromatous fibro-angiomatous, and giant-cell nature.

Axhausen and Hammer (8) classify epulides as follows (1) *Simple epulis* (*epulis granulomatosa*)—granulation tumors with unchanged tissue structure These growths are localized hypertrophies of the gums. They are chronic inflammatory in nature, due to carious or septic teeth, and appear as red, smooth, rounded, sessile or pedunculated masses growing from the alveolar periosteum or peridental membrane. (2) *Fibroid epulis* (*epulis fibromatosa*)—granulation tumors showing connective tissue maturation and fibrous tissue structure. This is the form most commonly encountered As a rule, they are small and firm, may be sessile or pedunculated, and have the color of the surrounding mucous membrane. They usually originate in the alveolodental periosteum, invade the bone of the alveolus, and tend to displace the teeth. (3) *Giant-cell epulis* (*epulis gigantocellularis*)—granulation tumors consisting of a proliferation of blood vessels, endothelial tubes, and giant-cells. These epulides are usually situated on the labial or buccal side of the alveolar process. They are slow in growth and basically benign but show a tendency to local recurrence They are believed to be identical with central giant-cell tumors (p 993) (4) *Sarcomatous epulis* (*epulis

sarcomatodes)—granulation tissue tumors with a predominant proliferation of mesenchymal basal cells They are usually soft and spongy and of the same color as the surrounding mucous membrane Microscopically, they are composed of interlacing spindle-cells in combination with a varying number of large multinuclear giant-cells This type of epulis grows rapidly but is only locally malignant

Small epulides produce no symptoms, but extensive growths cause deformity of adjacent structures and displacement of the teeth and predispose to ulceration necrosis of the gingival tissue

Simple epulides are best removed under local anesthesia An incision just beyond the limits of the tumor is made in the healthy mucous membrane and carried down to the bone Through the incision the growth is freed and removed The affected tooth is extracted, and the osseous margins of the alveolus are trimmed with a forceps The surrounding mucosa is undermined for a distance sufficient to permit of its approximation over the exposed bone

The removal of the other varieties of epulides must be accompanied by excision of a portion of the adjacent periosteum and bone One or 2 teeth are first extracted on either side of the tumor, and with a cutting forceps, saw, or chisel a V-shaped piece of bone incorporating the mass is resected Subsequently, an artificial denture may be provided to replace the loss If the epulis is of the giant-cell type, it will be necessary to open the cavity freely and scrape out the contents with a sharp spoon A close watch must be kept for symptoms of recurrence, and at the first sign of such an eventuality the treatment should be repeated

Osteitis Fibrosa Cystica

This condition, first described by von Recklinghausen (191) in 1891, is most common in children and young adults, and the most frequent site is the mandible. There are two varieties, general and local The generalized form is due to a hyperparathyroidism with a disturbance of calcium and phosphorus metabolism, the localized form is limited to one or more bones, the parathyroid gland and the blood calcium being unaffected In either case there is a demineralization of the bone and a fibrosis of the bone marrow resulting in the formation of cyst cavities composed of osteoid tissue replacing the normal bone Clinically, the condition is characterized by a progressive painless expansion of the bone with a tendency to spontaneous fracture

When the cysts are small and definitely localized, the treatment is confined to the spooning out of the soft proliferative masses until sound bone is reached When the involvement is extensive, it may be necessary to resect the mandible and later restore its continuity by the implantation of a bone graft (p. 1271). In either case surgical treatment should be followed by irradiation of the parathyroid glands (77, 82, 99, 109, 214)

Traumatic Cysts (*Hemorrhagic Cysts*)

Cystic cavities may form in the mandible as a result of trauma They occur most frequently in children and young adults and are due to absorption of the bony trabeculae of the cancellous bone as a result of intramedullary hemorrhages The diagnosis is made by a history of trauma followed by pain a[illegible] g of the bone X-ray examina-

tion shows a homogeneous rarified area of varying extent and smooth outline centrally located in the bone and apparently unconnected with the roots of the teeth. The treatment consists of the opening of the cyst through an incision in the gingiva and the evacuation of its contents. The residual cavity is then packed and allowed to heal by granulation.

Torus Palatinus

Torus palatinus is an exostosis in the region of the medial suture of the osseous palate. Ordinarily, it produces no discomfort, but in the case of edentulous patients it may interfere with the proper fitting of a denture and hence require removal. Excision may be accomplished under local anesthesia. An incision is made into the soft tissues over the exostosis. The margins are retracted, the bone is planed down with either a chisel or a burr on a dental engine, and the soft parts are sutured back into place (135)

Leontiasis Ossea

Leontiasis ossea is a diffuse hyperostosis beginning in the bones of the skull and spreading to other bones. The condition was recognized by Malpighi (154) in 1697, but its first clinical description was given in 1776 by Forçade (72) who studied the disease in his own son The case was quoted by Virchow as follows "Forçade was a surgeon of Perpignan who made observations on his own son, who, except for an attack of smallpox, was healthy up to the age of 12 years (1734) At this time his father opened the right lachrymal duct in the internal corner of the right eye, which discharged pus for a long time. Simultaneously, a large tumour, the size of an almond, formed in the nasal process of the upper maxilla and this increased in size to such an extent that at the age of 15, the cartilages of the nose were so compressed that the boy could only breathe through his mouth. Later, the disease spread to the lower jaw, involving the whole bone, except the articular extremities and the alveolar border In due course, nearly all the bones of the face were attacked and the patient's appearance at the age of 20 became monstrous, especially as exophthalmos supervened General weakness and complete blindness followed and at the age of 45, the man died from tuberculosis.'

The disease usually begins in early life, progresses slowly, and may become stationary at any time. It has been variously attributed to trauma, infection, heredity, and endocrine disturbances. The pathologic changes are those of either a chronic periostitis or of a diffuse osteitis, the process attacking one bone after another and being characterized by deposits of cancellous bone. Clinically, there is a marked thickening of the bones of the skull. In the face the condition most frequently attacks the upper and lower jaws, and in the vault it involves principally the frontal and temporal bones, the face assuming a leonine appearance. As the disease progresses, the expanding bones infringe upon adjacent structures. Thus pressure on the brain results in headache convulsions, and mental symptoms, and encroachment upon the nasal region causes obstruction to breathing The disease is incurable although x ray is of some value Endocrine therapy has been found useless. Surgery is indicated as a palliative measure for the removal of the bone causing pressure symptoms.

FACIAL PARALYSIS

Facial paralysis is a most unfortunate affliction, as it not only deprives the victim of the ability to express emotions through the play of the facial muscles, but also interferes with mastication, speech, and closure of the ipsolateral eye In addition to these physical disturbances, there are associated psychic phenomena, all of which threaten the patient's economic and social existence Thus it becomes a pressing surgical duty to alleviate the condition

Anatomy of Facial Nerve

A brief review of the anatomy of the facial nerve will pave the way for a more comprehensive understanding of the problem involved The facial nerve furnishes the face with all of its motor impulses except those activating the elevator muscle of the eyelid, the ocular muscles, and the muscles of mastication, it is secretory to the salivary glands, and through its chorda tympani branch it supplies the anterior ⅔ of the tongue with the sense of taste

The nucleus of the facial nerve lies deeply embedded in the pons varolii in line with the motor nuclei of the fifth and ninth cranial nerves The root pursues an extremely circuitous course through the pons, running first dorsally, then upward, next laterally above, and finally ventrally on the outside of the sixth nucleus It emerges from the groove between the pons and medulla in the same transverse plane as the eighth nerve Between its superficial origin and that of the latter nerve springs a small bundle called by Wrisberg (236) the "pars intermedia" The seventh, eighth, and pars intermedia run outward into the internal acoustic meatus, the seventh nerve lying in a groove on the upper and forepart of the auditory nerve and the pars intermedia lying between them The pars intermedia arises from the upper part of the glossopharyngeal nucleus, joins the facial nerve immediately after the latter enters the facial canal, and is directly connected with the cells of the geniculate ganglion It appears to represent the sensory root of the seventh nerve and forms the main constituent of the chorda tympani. At the bottom of the acoustic meatus the facial nerve enters the facial canal In this canal it runs first outward between the cochlea and vestibule until it abuts the inner wall of the tympanum, it then passes backward in the substance of the inner tympanic wall, above the fenestra ovalis, being here separated from the tympanum by a thin lamina of bone and the lining membrane of the middle ear, finally, it turns somewhat acutely downward behind the pyramid and [illegible] ympanic wall, to appear at the base of the skull at the stylomastoid foran[illegible] issuing from the styl[illegible] foramen the facial nerve runs downward [illegible] through the sub[illegible] parotid gland superficial to the external [illegible] behind the ramus jaw it divides into a [illegible]erior, or temporof[illegible] inferior, or cervi[illegible] sion, each of whi[illegible] into [illegible] ch are distribu[illegible] and submandib[illegible]

For surgical p[illegible] ranches of t[illegible] may be div[illegible] groups: (1) T[illegible] its course t[illegible] ous portion bone, (2) those [illegible] trunk at t[illegible] ull, and (3 from its two g[illegible] sions

(1) *The branch[illegible] rve given [illegible] ough of the temporal bon[illegible] superfi[illegible]*

cranial nerve, an anastomotic branch, communicating with the tympanic plexus, a branch extending to the stapedius, and one proceeding to the chorda tympani. In spite of its bony protection in this location the nerve is subject to inflammation and infection, and liable to accidental and operative injury

(2) *The branches issuing between the base of the skull and its final division* comprise the posterior auricular nerve, which arises just after the facial nerve has appeared at the base of the skull. It passes backward in the deep recess between the mastoid process and the external ear, communicating with the auricular branch of the pneumogastric Just below the preceding nerve emerges the nerve leading to the posterior belly of the digastric. One of its branches frequently joins the glossopharyngeal. The nerve to the stylohyoid muscle may be given off along with the last in one common trunk or separately at the same level. Finally, the lingual branch passes on the outer side of the stylopharyngeus muscle to the side of the pharynx, where it communicates with the ninth, and then proceeds between the palatoglossus and the tonsil to the base of the tongue

(3) *The two great terminal divisions* are distributed in a manner which may be summarized as follows Running forward in the substance of the parotid gland, in which they cross superficially to the external carotid artery and temporomaxillary vein, the *temporofacial division*, after receiving a stout branch from the auriculotemporal nerve, subdivides into the temporal, zygomatic, and infra-orbital branches, and the *cervicofacial division* into the buccal, mandibular, and cervical branches, the parotid duct separating the infra-orbital from the buccal nerve With the exception of the cervical nerve, these ramifications spread over the face each occupying roughly the region corresponding to the name it bears (fig 598) By interlacing with each other and with the various cutaneous branches of the fifth nerve, they form an intricate network and supply all the facial muscles, including the buccinator, the epicranius, and the anterior muscles of the auricle. The cervical branch emerges from the parotid gland behind the angle of the lower jaw, runs downward and forward under the platysma over the inframandibular and adjacent region of the neck, communicating freely with the great auricular and superficial cervical nerves, and supplying the platysma on its under surface.

It should, moreover, be stated that the zygomatic muscles and the caput infraorbitale lie above the infra-orbital branch, and the risorius, triangularis, and quadratus labii inferioris cross the mandibular branch, but with these exceptions the branches of the facial nerve are superficial.

Branches from Temporofacial Division The temporal branch of the temporofacial division of the facial nerve passes upward through the parotid gland over the zygoma, and divides into branches which supply the orbicularis oculi, epicranius, and corrugator supercilii. Its branches form numerous communications with each other, with the zygomatic and with the auriculotemporal, temporal, lacrimal, and supra-orbital branches of the fifth nerve. The zygomatic branch runs forward over the zygoma and is distributed mainly to the orbicularis oculi. The infra-orbital branch emerges from the anterior border of the parotid gland just above the parotid duct, and divides into branches which radiate to the region of the face between the orbit and the mouth. It supplies the buccinator and orbicularis oris muscles.

Branches from Cervicofacial Division The cervicofacial division runs downward and forward in the parotid gland, crossing the external carotid artery It divides into three

branches, as follows: The buccal branch emerges from the parotid gland beneath the parotid duct, crosses the masseter muscle, and breaks up into subdivisions leading to the buccinator and orbicularis oris The mandibular branch crosses the masseter muscle and facial vessels on the body of the mandible, and beneath the risorius and depressors of the lower lip passes toward the chin. It supplies the risorius, triangularis, quadratus labii inferioris, and mentalis

The fact that the frontalis, orbicularis oculi, and corrugator supercilii are not involved in cortical facial paralysis furnishes clinical evidence of a connection between the facial nerve and the oculomotor nucleus, which probably takes place through the posterior longitudinal bundle (79).

Etiology

Facial paralysis may result from a lesion anywhere along the pathway of the facial fibers—i.e , in the motor cells of the precentral gyrus, the supranuclear fibers, the nucleus itself, or the fibers extending from the nucleus to the muscular distribution of the nerve Obviously, the extent of the paralysis will depend upon the part of the nerve involved. For example, a lesion of the main trunk of the facial before its point of division would cause a paralysis of all the expression muscles of the face, whereas a lesion of the temporal branch which supplies the orbicularis oculi would merely interfere with closure of the eyelids

Intracranially, the nerve may be injured by pressure from tumors, hemorrhage, abscesses, aneurysms, and inflammatory conditions of the brain, such as encephalitis and meningitis. Nuclear paralysis is usually inflammatory in origin and secondary to acute infectious diseases, notably diphtheria and anterior poliomyelitis Lesions of the peripheral branches of the facial nerve may be classified etiologically as follows.

(1) *Primary Facial Paralysis (Idiopathic or Acute Facial Paralysis, Bell's Palsy)*

Facial paralysis unassociated with any definite cause has by common usage come to be known as "Bell's Palsy " This condition has been variously attributed to exposure to cold, "rheumatism," toxic neuritis, periostitis, latent otitis media (192), etc It is generally acknowledged that the underlying pathologic factor is a swelling of the nerve in the unyielding facial canal with a consequent interruption of its function.

(2) *Secondary Facial Paralysis*

Facial paralysis may be secondary to (a) Mastoid operations Coming on immediately after the operation, it may be the result of severance of the nerve just below the bend, of hemorrhage within the canal, or of traction. If the onset is delayed for several days, the condition is probably caused by neuritis or edema (b) Operations in the parotid region in which the nerve has been inadvertently cut (c) Fractures of the base of the skull in the region of the temporal [illegible] Pressure on the nerve from inflammatory or suppurative processes in [illegible] ost commonly encountered in children), or from ab[illegible] [illegible]rotid gland, neck, or mandible

Diagnosis and Prognosis

Localization of the site of the lesion is essential to proper treatment, and, despite the circuitous course of the facial nerve, this presents little difficulty if its anatomic and physiologic characteristics are borne in mind.

Supranuclear Lesions (Upper Motor Neuron Paralysis)

Supranuclear lesions arise from injury of the fibers in any part of their course between the cortical motor nuclei in the rolandic area and the nucleus of the facial nerve. Facial paralysis of this type is usually associated with a hemiplegia on the same side The upper facial muscles notably the orbicularis oculi, epicranius, and corrugator, frequently escape thus the patient may be able to wrinkle the forehead and close the eye on the affected side voluntarily This is explained by the fact that a few fibers reach the nucleus from the cerebral cortex of the same side, and it is along this uncrossed path that these muscles are innervated. Generally, voluntary movements are more seriously impaired than are emotional, and as in other types of upper motor neuron paralysis, both the affected muscles and nerves respond normally to electrical stimulation

Nuclear Lesions

Nuclear lesions are associated with damage to contiguous cranial nuclei, especially the sixth, causing the eye on the same side of the paralysis to turn inward, due to loss of function of the lateral rectus muscle If the *upper part of the pons* is involved above the level where the facial fibers cross to be distributed to the opposite side of the face, the facial paralysis will be on the same side as the hemiplegia. If, on the other hand, the injury is in the *lower part of the pons*, there will result paralysis of the face on one side and hemiplegia on the opposite (crossed paralysis) Facial paralysis of intracranial origin is but incidental to a more serious brain lesion, such as cerebral hemorrhage, and the prognosis will be in direct ratio to the severity of the underlying cause

Infranuclear Lesions (Lower Motor Neuron Paralysis)

A lesion *between the geniculate ganglion and the origin of the chorda tympani* will cause a loss of taste sensation in the anterior two-thirds of the tongue and a decrease in the secretory activity of the salivary glands on the same side The reason for this is that the secretory salivary fibers travel down the nerve of Wrisberg and continue, posterior to the salivary ganglion, as far as the facial nerve, leaving it by way of the chorda tympani If the injury is at the point where the facial nerve sends forth a branch to the stapedius muscle, there will be an interference with hearing, if at the place where it emerges from the *stylomastoid foramen*, a typical picture is presented The face on the affected side is expressionless and immobile and responds to neither voluntary nor emotional stimuli Owing to the loss of muscle tone the eyebrow is lowered, the nasolabial folds are obliterated, and the angle of the mouth sags, giving the face a flat and ironed-out appearance. In time the muscles atrophy and are drawn toward the unaffected side by the unopposed pull of the healthy muscles. Because the epicranius is affected the wrinkles in the forehead are effaced. The paralysis of the orbicularis

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Diagnosis and Prognosis

Localization of the site of the lesion is essential to proper treatment, and, despite the circuitous course of the facial nerve, this presents little difficulty if its anatomic and physiologic characteristics are borne in mind.

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oculi leads to a prolapse of the opening of the lacrimal duct, in consequence, tears flow over the eyelid, the lower lid droops, the palpebral fissure is widened, and the constant exposure of the eyeball predisposes to conjunctivitis. Furthermore, the involvement of the orbicularis oris produces an inability to smile, to purse the lips, bare the teeth, or enunciate labial consonants. Paralysis of the buccinator permits food to collect between the cheeks and teeth and an escape of saliva from the affected corner of the mouth. Involvement of the stylohyoid and posterior belly of the digastric causes a lowering of the base of the tongue and further interference with speech. At times of emotional stress the deformity is exaggerated. Finally, as in all forms of lower motor neuron paralysis, both the affected muscles and the nerves show reaction of degeneration.

The condition has been brilliantly described by Bell (20): "The muscles of the cheek on the left side are wasted and there appears to remain nothing but the thin integuments which hang upon the side of the face, as if dead, without having any action in them, or wrinkles, as in the right cheek, and when he speaks, this cheek is alternately puffed out and then collapsed, the air first distending it as if it were a bag, and then escaping at the angles of the mouth. His whole mouth is drawn to the right side, thus producing most remarkable distortion of the face. Whatever action there is in the mouth is altogether owing to the contraction of the muscles on the right side of it, the left angle hangs loose, and is quite passive, and the saliva is allowed to flow constantly out upon the lower lip on this side."

The *prognosis* of extracranial lesions will depend upon the nature of the underlying cause and, to a lesser extent, upon the time at which treatment is instituted. In the idiopathic type which supervenes suddenly without definite cause, spontaneous recovery takes place in 80 to 85 per cent of the cases within 4 to 6 weeks, and in the more severe cases in 3 to 5 months. Tumarkin (227) observes that if there is no pain or impairment of taste sensation, the chances for recovery are 25 to 1. Erb (63) laid down the following rules: (1) If there is no change in faradic or galvanic stimulation, the lesion is slight, and recovery may be expected in from 14 to 20 days. (2) If the faradic and galvanic excitability of the nerve is only lessened and that of the muscle increased to the galvanic current, and the contraction formula AC is greater than KC, recovery will take place in 4 to 6 weeks. (3) When the reaction of degeneration is present and the mechanical excitability is altered, the prognosis is relatively unfavorable.

If the nerve has been severed as a result of operation or accident, recovery is unlikely without surgical restoration of continuity, but if the nerve is merely contused or even partially severed, as evidenced by an incomplete paralysis, the chances of spontaneous recovery are good. Should the nerve be compressed within the facial canal because of inflammatory or suppurative exudates, the outcome is usually satisfactory, provided an immediate decompression is carried out.

Conservative Treatment

Unless the paralysis is the result of a definite lesion, such as severance of the nerve or compression, a reasonable time for spontaneous recovery should be permitted to elapse before surgical treatment is instituted. During this period measures must be taken not only to preserve the tone and prevent overstretching of the affected muscles, but also to prevent shortening of their antagonists on the other side. The tendency to

muscle-stretching can be minimized by the use of simple mechanical devices. The sagging angle of the mouth and cheek may be splinted with adhesive tape or with elastic bands stretched between hooked adhesive strips, one at the corner of the mouth and the other on the forehead Or a hook may be inserted into the angle of the mouth and suspended from the auricle Electrical treatments for the maintenance of muscle tone are probably of little value since on the one hand they cannot be expected to activate muscles already paralyzed, and in the case of those muscles which have begun to recover active movement will do more to hasten the process than electrical stimulation. Gentle massage will help to conserve the volume and nutrition of the affected muscles, but it must be done carefully otherwise, the stretching of the atrophied and fibrotic muscles will result in more harm than good. A dark lens should be worn during the day to protect the eye against trauma, and at night a bandage should be applied. As a precaution against infection it is advisable to irrigate the eye at frequent intervals with a 5 per cent argyrol solution.

If in spite of conservative treatment the paralysis has persisted over a period of 6 months without material improvement, surgical intervention is indicated Should there be some evidence of regeneration, however, operation is deferred for another 6 months After this period the longer the procedure is postponed, the less the chance of recovery Stracher (220) reported 66 per cent recoveries when operation was performed 4 to 6 months following injury and only 24 per cent when it was carried out 7 to 22 months afterward.

Surgical Treatment

The numerous surgical procedures advocated for the relief of facial paralysis may be divided into two groups (1) Those which attempt to reanimate the facial muscles and envisage (a) decompression of the nerve, (b) direct end-to-end anastomosis, (c) nerve-grafting, (d) facial anastomosis with contiguous motor nerves, and (e) direct neurotization Whether or not the above operations are warranted will depend upon the condition of the muscles. As long as they are capable of responding to stimulation, the restoration of continuity of the nerve may bring about a return of function. If, on the other hand, the muscles fail to respond to galvanism and have undergone atrophy and fibrosis, little can be expected as a result of these operations, since the repaired nerve would have no functioning muscle fibers to innervate. In the latter circumstance all that can be hoped for through surgery is (2) to conceal or minimize the deformity consequent upon the paralysis by mechanical measures comprising (a) fascial suspension (b) muscular suspension, and (c) skin excisions.

Reanimation of Facial Muscles

(1) **Decompression.** The operation of decompression is indicated when the paralysis is known to be due to pressure on the nerve from tumors abscesses, exudates, or sequestra, and should be carried out as soon as possible after diagnosis (14), while the nerve still retains its electrical excitability However, in the case of paralysis associated with fracture of the base of the skull but involving no damage to the facial canal surgery should be delayed, since in such instances the nerve is usually contused or compressed by a hematoma and is likely to recover spontaneously If the patient

does not come under observation until some time after the onset of paralysis, and partial recovery has taken place, only to be arrested for several weeks or months, the problem is more difficult Here the improvement of function anticipated from the surgical procedure must be weighed against the possible destruction of the remaining function by the operative trauma

In the idiopathic types of paralysis the indication for decompression is less definite, and the question of operation is subject to debate In all such instances Ballance and Duel (14) advise immediate decompression, but if their suggestion were followed, there would obviously be a great deal of unnecessary surgery, in view of the fact that 80 to 85 per cent of these cases recover spontaneously Until the fate of the 15 to 20 per cent who fail to recover can be determined beforehand, the advisability of early operation must remain controversial

In the decompression operation the facial canal is opened in the usual manner, the nerve is exposed, the compressing agent removed, and the sheath of the nerve slit to afford further relief from pressure (fig 625)

(2) **Direct Nerve Suture.** When the facial nerve has been inadvertently severed during the course of an aseptic operation, the ideal procedure is an end-to-end anastomosis, and this should be carried out as soon as the damage is ascertained In any event it should be performed within the first 72 hours, while the nerve can be identified by the use of the faradic current After this period identification of the distal end is possible only by resort to tedious dissection If, on the other hand, the nerve has been severed under septic conditions, as, for example, by accidental trauma, it is advisable to delay the repair until healing is complete, so that the operation may be performed without danger of infection (43, 55, 160, 170)

The nerve may have been severed (a) in the facial canal, (b) in its course from the stylomastoid foramen to the parotid gland, or (c) along its path from the parotid gland to its final distribution

(a) If the lesion is situated in the facial canal, the canal is opened from the stylomastoid foramen to the point of injury and the divided nerve-ends identified Irreparably damaged tissue and neuromata, if present, are removed, and should the remaining defect permit of direct union, the nerve-ends are accurately approximated in the manner described on page 292 If after excision of the injured tissue the defect is found to be too extensive for direct closure, it may still be possible to bring the nerve-ends together by a rerouting of the nerve along a shorter course Ballance (12) and Duel, however, were not in favor of this procedure, on the grounds that the space thus gained is at the most 3 mm , the new bed cannot compare with the original one, and the vascular connections in the aqueduct are destroyed

Bunnell (43) advocates rerouting of the nerve, provided the interval between the ends does not exceed 16 mm beyond the bend, or genu, or 23 mm at the geniculate ganglion He describes the technic as follows "The facial nerve is first located as it emerges from the stylomastoid foramen The nerve is uncovered from below upward, the mastoid process being chiseled away and the nerve exposed as it lies in the fallopian canal until the lesion is located Care is taken to preserve the external meatus intact in order to maintain a clean field The bone should be chiseled away widely to afford space in which to work The nerve is also exposed above the lesion as it lies in the fallopian canal and is uncovered downward to the lesion, where it will be found to terminate in a neuroma if it has been severed as long as three months Both nerve

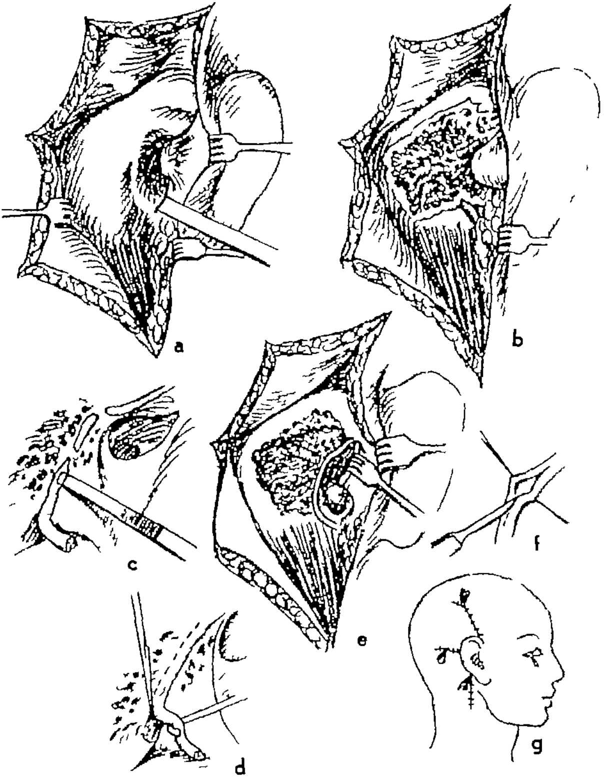

FIG. 625 Decompression of facial nerve. *a*, soft tissues incised and retracted, to expose mastoid tip and meatal wall. Chisel indicates point at which removal of auditory plate is begun, to expose stylomastoid foramen. *b*, mastoid cortex and cells removed. Facial nerve exposed from stylomastoid foramen to its entrance into parotid gland Posterior meatal wall removed exposing eminence of lateral semicircular canal. *c* facial nerve in its vertical and tympanic course uncovered with fine sharp chisel. *d* sheath of facial nerve separated from periosteum with cataract knife *e* nerve freed from facial canal throughout its vertical and tympanic course. *f* nerve sheath slit, to decompress nerve. *g* Incision closed. Sites of drainage indicated. (Ney)

ends are trimmed back boldly until good axon bundles present. As the nerve leaves the stylomastoid foramen to reach the parotid gland, it turns at an angle of 105° If, however, the vaginal process and part of the tympanic plate of the temporal bone are chiseled away, the nerve can be made to run straight from the parotid gland to the middle ear It then takes the course of the hypotenuse of the triangle, and 1 cm of length is gained By freeing the nerve well into the parotid gland, 2 mm more is gained, and by displacing the parotid gland upward and suturing it there to the attachment of the digastric muscle or to the bone, another 4 mm is gained Thus, if the lesion is at the bend, 16 mm can be gained by rerouting

"If the lesion is at the geniculate ganglion, 7 mm additional can be gained by rerouting, making a total of 23 mm For this a deep notch is chiseled from the vaginal process and the tympanic plate, and the nerve is passed through this in a direct line from the parotid gland to the geniculate ganglion, in front of the external meatus between its soft anterior wall and the anterior bony wall of the meatal canal The distance the nerve traverses is then 44 mm compared with 61 mm, which is the length of the course the nerve normally takes in the adult male from the geniculate ganglion to the posterior border of the mandible To this saving of 17 mm, the difference between 44 and 61, there may be gained 2 mm more by teasing the nerve from the parotid gland and 4 mm by displacing the gland upward, making a total of 23 mm. saved by rerouting Though the actual measurements vary, this ratio is approximately correct"

(b) If the point of severance lies in the course of the nerve between the stylomastoid foramen and the parotid gland, end-to-end anastomosis is comparatively simple because of the exposed position of the nerve in this location

(c) When the lesion affects the distal branches of the nerve, end-to-end anastomosis is difficult and often impracticable, except in the case of the main divisions, because of the small caliber of the peripheral fibers Repair by direct approximation can be accomplished only by exposing the nerve before it divides and tracing each individual fiber by blunt dissection

(3) **Nerve Grafts** If the nerve defect is too extensive to be repaired by direct approximation, the free transplantation of an autoplastic nerve graft between the proximal and distal ends is the method of choice, but even here under the most ideal conditions and with the best technical skill, the results are still far from satisfactory Tremors, disharmonious functioning, and lack of synchronous activity may remain as residual symptoms These are assumed to be due to the fact that in the descent of the central axon into the peripheral fiber during regeneration some of the fibers destined for the lower part of the face are sidetracked to muscles of the upper part

The repair of facial nerve defects by means of nerve grafts was advocated as far back as 1873 by Létiévant, and since then many similar attempts have been recorded (*4, 15, 44, 158, 160, 173, 211, 223*) But the results were not encouraging until 1931, when the extensive work of Ballance and Duel (14) demonstrated the practicability of restoring voluntary and emotional control to paralyzed facial muscles by the use of such transplants The experimental and clinical results of these two investigators have aroused great interest and will probably have a profound influence on the whole subject of peripheral nerve surgery

Theoretically, the facial nerve is particularly adapted for the reception of a nerve graft Because of its small caliber the defect can be bridged by a transplant of equal

size. This is a distinct advantage, since small nerve grafts are more readily nourished by the surrounding lymph, whereas in those of larger caliber it is relatively difficult for the lymph to penetrate the nerve substance, and a central necrosis is likely to supervene before vascularization is established. Furthermore, the facial nerve is purely motor, and disorientation of its filaments is less likely than in the case of a mixed nerve. Finally, the facial canal serves to protect and immobilize the grafted ends.

Source of Graft Any nerve, whether sensory or motor, may be used as a graft. Ballance and Duel in their experimental work employed reversed and unreversed sections from the facial, intercostal, descendens noni, nerve of Bell, and the anterior femoral cutaneous. The last named was their final choice, since it supplied any required length, could easily be located, and its interruption occasioned only a negligible area of anesthesia. Either fresh or degenerated grafts may be used. Duel (14), after trials with both varieties, came to the conclusion that the latter were superior, for reasons given on page 190 Briefly, a fresh nerve graft must undergo Wallerian degeneration, and the degenerated elements must be removed by the circulation before new axons from the central end can grow down to the peripheral part of the nerve, in a degenerated nerve on the other hand, the empty neurilemmal tubes are ready to receive the nerve fibers.

Preparation of Graft If a degenerated graft from the anterior femoral cutaneous nerve is to be employed, it is prepared 2 weeks prior to the resection A long transverse incision is made in the thigh 10 to 12 cm. below the groin The internal saphenous vein is identified, and the nerve is sought 1 to 3 cm. lateral to the vein, at a point where it pierces the fascia lata over the sartorius and runs into the thigh. When the selected branch has been found it is cut and marked for future identification by means of a suture of heavy black silk, or its distal segment may be enclosed in a narrow strip of dental gold or introduced into a sterile rubber tube. The wound is then closed and the nerve left undisturbed for 2 or 3 weeks, when Wallerian degeneration will have taken place.

Preparation of Bed to Receive Graft The facial canal is opened as for a mastoid operation and the exit of the facial nerve at the stylomastoid foramen identified to serve as a landmark. The outer wall of the facial canal up to the bend between the oval window and the bulge of the semicircular canal is resected, and the nerve is exposed for 4 to 5 mm. above and below the injury The nerve sheath is grasped with a fine-toothed dissecting forceps in the direction of the long axis of the nerve, and with a fine sharp knife the neuroma at the proximal end is progressively sliced off at right angles to the nerve until normal fasciculi present. The scar tissue of the distal end is then excised in a similar manner During the dissection care should be taken to prevent drying out of the nerve Hemostasis is secured by pressure with cotton pledgets moistened in normal salt solution The length of the defect is measured with a pair of calipers, so that a graft of corresponding size may be cut Finally, the wound is packed with gauze wrung out of normal salt solution and attention is directed to the procuring of the graft.

Removal of Graft The donor nerve is obtained in the manner already described (p 192) and transferred immediately to the facial canal.

Placing of Graft When the graft has been procured, the gauze pack is removed from the facial canal, blood-clots are evacuated by irrigation with warm normal salt

solution, and the graft is interposed between the proximal and distal ends of the nerve. If both extremities of the severed nerve lie within the canal, it is unnecessary and undesirable to suture the graft in place, inasmuch as the serum will glue the contiguous ends together and fix the transplant in a fibrinous bed (14) (fig 626-a) If, however, the canal has been resected to such an extent as to offer insufficient immobilization for the graft, the sheath of the transplant is united to the proximal and distal sheaths of the nerve segments by means of 1 or 2 sutures of #000000 black silk mounted on the finest curved needle (fig 626-b)

Dressing and After-Care Over the graft is placed a thin layer of dental 22.5 carat gold leaf as a protection against its displacement when the dressing is renewed This is overlaid by a thin layer of rubber tissue, perforated to permit of drainage Over this are spread several small gauze packs wrung out of sterile normal salt solution and held in place by means of a bandage For a week to 10 days the dressings are changed daily with great gentleness to avoid disturbance of the graft At the end of this time the transplant will have become embedded in granulation tissue

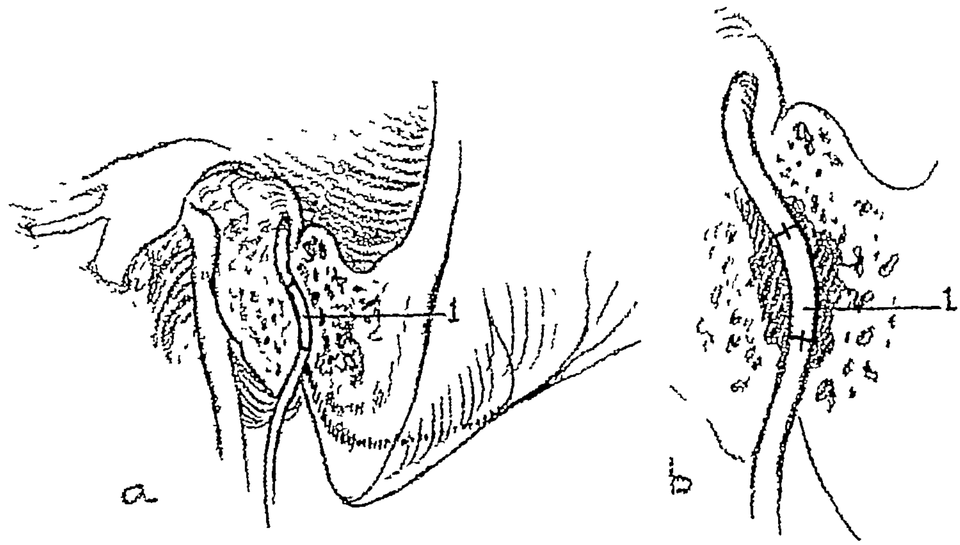

Fig 626 Repair of facial nerve by nerve graft *a*, when both ends of severed nerve lie within canal, nerve graft *1* laid between ends of facial nerve without suture *b*, when canal affords insufficient immobilization, graft *1* sutured in place For details, see text (Ballance and Duel)

The return of function following nerve grafting is gradual, as a rule, it begins 2 to 4 months after operation and continues up to 2 or 3 years, after which period no further improvement can be expected. Restoration of muscle tone appears first, followed by a gradual resumption of voluntary control which starts in the oral sphincter and extends to the upper parts of the face Throughout the regenerative process the paralyzed muscles should be strapped and massaged to prevent stretching

(4) **Facial Anastomosis with Contiguous Motor Nerves** Motor control to the paralyzed muscles may also be restored by union of the cut distal extremity of the paralyzed facial nerve with the severed central end of some adjacent motor nerve, the motor pathway being thus re-established between the cortex and the facial muscles. Although such an anastomosis restores symmetry to the face in repose, and re-establishes muscle tone, together with some degree of voluntary control, nevertheless the procedure has definite objectionable features It effects no restoration of emotional control. Voluntary movement of the part which the donor nerve supplies is as-

sociated with grotesque movements of the facial muscles. Finally, the muscles originally activated by the donor nerve undergo atrophy, with a crippling of the part. For instance, if the hypoglossal nerve is used for the anastomosis movement of the tongue will be accompanied by facial grimaces, and there will be an interference with speech, mastication, and deglutition, due to partial atrophy of the tongue.

Anatomically, the nerves most suitable for facial anastomosis are the spinal accessory, the hypoglossal, and the glossopharyngeal. The spinal accessory, being superficial and easily accessible, was the first to be experimented with. Faure and Furet (67) performed such an operation in 1898 and reports of similar procedures with modifications and improvements of technic soon followed (16 55 89 93, 121, 128, 131 155 231) This type of anastomosis produces atrophy of the trapezius and sternomastoid muscles and results in distressing associated movements, for instance, an attempt to close the eye is likely to be accompanied by an elevation of the ipsolateral shoulder, or, conversely the raising of the shoulder may cause a lowering of the eyelid An interesting illustration of such simultaneous movements is given by Ballance, Ballance, and Stewart (13) who report the case of a patient subjected 9 months previously to an operation for an injury to the left facial nerve The details are as follows "The flaccidity of the face had disappeared, so that when at rest it was practically symmetrical. No voluntary movement could yet be performed without simultaneous elevation of the shoulder Moreover the facial movements were so easily elicited by slight shoulder movements that the patient had to carry her parasol or umbrella in the right hand instead of the left, otherwise involuntary facial movements so readily occurred that awkward misunderstandings with strangers resulted."

In order to overcome the deformity discomfort, and inconvenience occasioned by atrophy of the sternocleidomastoid and trapezius muscles following division of the spinal accessory Grant (91) suggested that an additional anastomosis be made between the distal end of the latter nerve and the descendens hypoglossi

The generally unsatisfactory results of facio-spinal accessory anastomosis led to the use of the hypoglossal nerve, on the grounds that the resultant atrophy of half of the tongue was less distressing than paralysis of the shoulder, and that the associated movements of the tongue accompanying facial movement were hidden from view Moreover, it was assumed that because of the close proximity of the center of speech and that of the facial movements in the cortex co-ordinate impulses to the facial muscles would be more readily established. Furthermore the paralysis of the tongue consequent upon the use of the hypoglossal nerve could be to a certain extent relieved if the distal end of the nerve were united with the proximal extremity of the descendens hypoglossi The greatest drawbacks to the use of the hypoglossal nerve are its inaccessibility and its close relationship with important structures, such as the external carotid artery and the pneumogastric nerve. The first surgeon to utilize this nerve was Koerte (127) Since then it has been frequently employed (15, 75, 120, 188)

Technic The same principles which apply to nerve-suturing in general also obtain here and for details the reader is referred to page 291 As in the case of all nerve sutures, primary union is essential to success and this requires an aseptic field, elimination of scar tissue, and absolute hemostasis. The nerve ends are approximated with the finest arterial silk mounted on an atraumatic needle, and the stitches are passed in such a manner that the neural structures will lie in contact without the slightest tension As a precaution against cicatricial contraction, the anastomosed

extremities are either placed in a vascular bed, such as neighboring muscle, or are covered with a layer of fat

In order to expose the facial nerve, a vertical incision is made through the skin and superficial fascia beginning at the mastoid process and following the anterior border of the sternomastoid muscle for a distance of 7 to 12 cm, care being taken to avoid opening the parotid fascia The platysma is cut through as far as the anterior border of the sternomastoid muscle, and the muscle is retracted downward The posterior auricular vessels are tied and cut. The parotid gland is then freed by blunt dissection and drawn forward, and the digastric muscle downward In the intervening space the nerve is sought at a depth of 2 5 cm, on a level with the lobule of the ear When found, it is marked for future identification by means of loops of silk passed through the

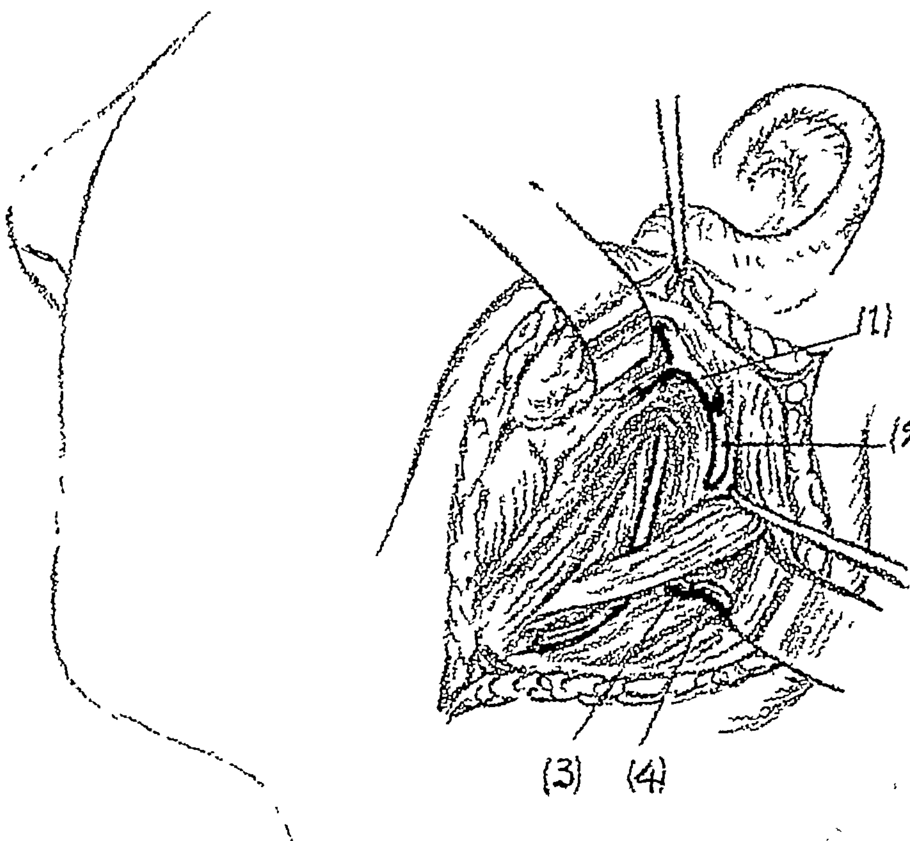

Fig 627 Spinofacial anastomosis *1*, distal end of facial nerve united to *2*, … accessory *3*, proximal end of descendens hypoglossi sutured to *4*, distal end of …

epineurium and is sectioned at the point where it emerges fro… foramen The remaining steps of the procedure will depend u… nerve to be used for the anastomosis

If the spinal accessory is to be employed, it is sought a little b… muscle, where it runs downward and outward toward … The transverse process of the atlas will serve as a bo… the nerve is cut and its proximal end united to the d…

If the hypoglossal nerve has been chosen, it is so… at the point where it turns forward over the occipital a… From here it is traced backward and cut just proxim… branches, and its proximal extremity is united to the di…

For the first few days after operation the patient's head is immobilized to prevent traction on the anastomosed ends. The after-care is the same as that following nerve-grafting operations (p 193)

Attempts have been made to neutralize the action of the antagonistic muscles by the excision of the superior cervical sympathetic ganglion (137), on the assumption that (1) each facial nerve sends a branch to the opposite eye which branch, however,

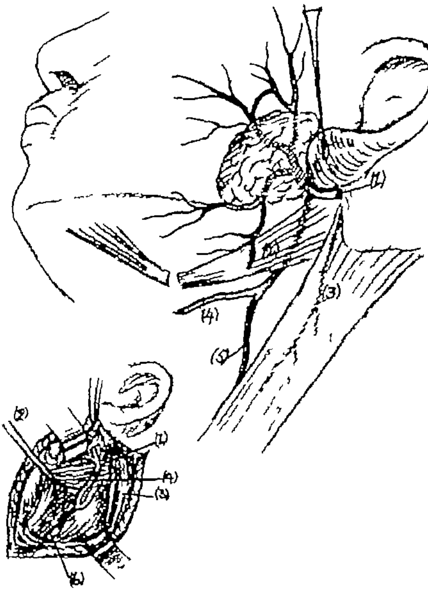

FIG. 628. Faciohypoglossal anastomosis *1*, facial nerve. *2* digastric muscle. *3* spinal accessory nerve. *4* hypoglossal nerve Insert shows distal end of facial nerve *1*, sutured to proximal end of hypoglossal *4* and rami descendens joined to distal end of hypoglossal *6* Sternomastoid *3* and digastric *2* retracted, to expose nerves.

becomes effective only when the innervating sympathetic nerve is cut (116), that (2) in some cases of facial paralysis the affected eye can be closed but only simultaneously with the other eye (232) and that (3) the nerve impulse is somehow associated with the vasomotor apparatus (3) Surgeons who have resorted to this procedure report that it produced a marked improvement in muscle tone and facial expression, but the method has found few adherents, owing to the fact that it results in the production of Horner s syndrome.

extremities are either placed in a vascular bed, such as neighboring muscle, or are covered with a layer of fat

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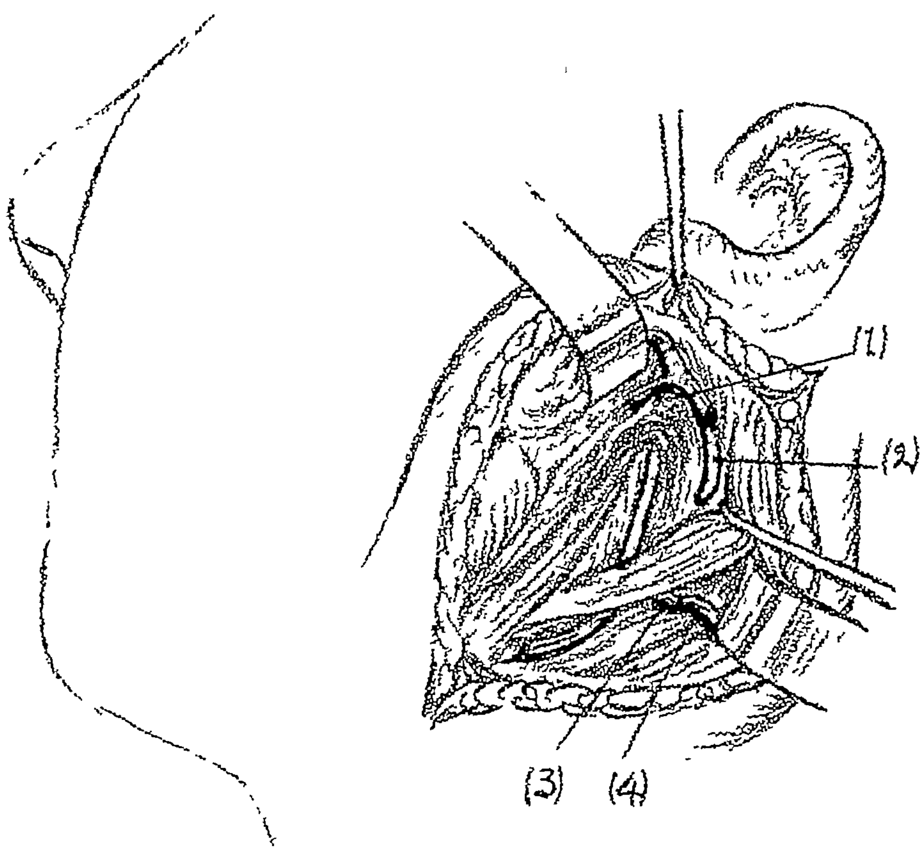

FIG 627 Spinofacial anastomosis *1*, distal end of facial nerve united to *2*, proximal end of spinal accessory *3*, proximal end of descendens hypoglossi sutured to *4*, distal end of spinal accessory

epineurium and is sectioned at the point where it emerges from the stylomastoid foramen The remaining steps of the procedure will depend upon the particular nerve to be used for the anastomosis

If the spinal accessory is to be employed, it is sought a little below the digastric muscle, where it runs downward and outward toward the sternomastoid (fig 627) The transverse process of the atlas will serve as a bony landmark When identified, the nerve is cut and its proximal end united to the distal extremity of the facial

If the hypoglossal nerve has been chosen, it is sought below the digastric muscle, at the point where it turns forward over the occipital artery on the hypoglossus (fig 628) From here it is traced backward and cut just proximal to its division into terminal branches, and its proximal extremity is united to the distal segment of the facial

For the first few days after operation the patient's head is immobilized to prevent traction on the anastomosed ends. The after-care is the same as that following nerve-grafting operations (p 193)

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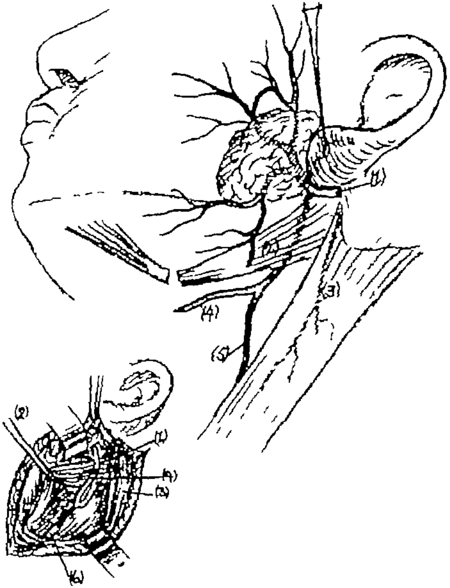

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(5) **Direct Neurotization** Attempts have been made to reanimate the paralyzed facial muscles by a direct implantation into the muscle substance of the cut proximal ends of the hypoglossal nerve, in the hope that the nerve fibers will grow into the surrounding muscular tissue (92, 180) This procedure has found few advocates, for it has all the objectionable features of nerve anastomosis, and the probability of functional restoration is less assured

The operation consists in the exposure of the hypoglossal nerve in Lesser's triangle, situated between the body of the mandible and the two bellies of the digastric muscle The terminal branches are dissected free An incision is then made along the nasolabial fold, and through this opening the muscles converging at the angle of the mouth are separated The hypoglossal nerve, previously freed, is drawn forward through a subcutaneous channel beneath the digastric and stylohyoid muscles and anchored to the paralyzed muscles

Mechanical Suspension of Paralyzed Muscles

(1) **Fascial Suspension** Mechanical suspension of the paralyzed muscles by the insertion of subcutaneous loops of fascia lata is obviously powerless to effect a return of voluntary or emotional control, but it does serve to relieve the distortion by overcoming the pull of the unaffected muscles The procedure is indicated in the case of nerve defects which are considered irremediable—as, for example, following a facial injury in which the terminal ends of the nerve have been severed—or when the muscles are so atrophied or fibrosed that they are incapable of responding to innervation Fascial suspension is also valuable as an adjunct to nerve-grafting and nerve anastomosis, inasmuch as the implanted fascia acts in the capacity of a cock-up splint and prevents overstretching of the muscles while the nerve is undergoing regeneration Indeed, some surgeons prefer fascial suspension to nerve anastomosis, on the grounds that the latter operation at best results in improvement of the deformity during repose, and emotional control is restored only after a prolonged period of re-education and even then leaves the patient with distressing associated muscular movements

In the early attempts at mechanical suspension of the paralyzed facial muscles aluminum bronze wire was looped around the muscles and attached to the zygoma (45, 164) Similar operations were later performed with subcutaneous loops of silk According to Kirschner (122), the first to use fascia lata for muscle suspension was Payr (179) who employed it for the relief of blepharoptosis Stein (216) was the first to apply the method to facial paralysis, and states in substance that when one recalls the permanent benefits derived from the implantation of strips of fascia lata in the treatment of ptosis, one naturally favors the use of this material, and that an autoplastic tissue which becomes integrally a part of its new surroundings is obviously superior to a foreign body like wire which tends to oxidize and break But to Blair (26, 27) must be given the credit of standardizing and popularizing the method

Technic Preliminary to operation the buccal, orbital, and nasal cavities must be completely freed of infection After the removal of a strip of fascia lata of the required length (p 197), the affected side of the face is prepared, draped, and anesthetized A small incision is made in front of the auricle, just above the tragus, to expose the parotid fascia (fig 629) Through this opening an unthreaded Blair's fascia needle is carried subcutaneously in a plane superficial to the parotid gland to a point just

beyond the philtrum, where it is made to emerge through a small incision A strip of fascia 2 to 3 mm. wide is locked in the eye of the needle, and the instrument is withdrawn and disengaged the ends of the fascia being left projecting through both wounds. The empty needle is then reinserted through the original preauricular incision and passed along another subcutaneous path, to emerge at the incision beyond the philtrum. Here it is threaded with the projecting end of the fascia and is withdrawn, carrying the fascia out by way of the initial opening, so that it will form a loop at the site of the philtrum and its free ends will present through the preauricular incision. Another strip of fascia is passed in a similar manner through the preauricular incision to form

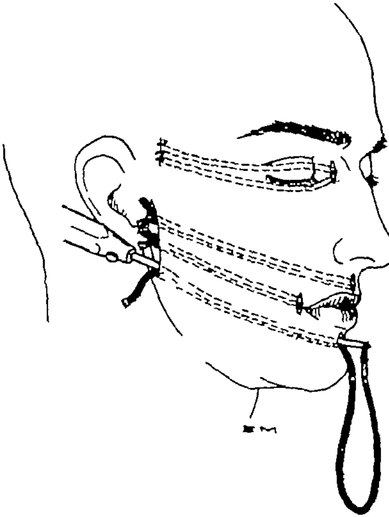


Fig 629 Suspension of paralyzed facial muscles by use of fascial bands. For details, see text.

a loop at the angle of the mouth, and a third to a point in the lower lip corresponding to that in the upper lip The two free ends of each of the three loops projecting from the preauricular incision are then tightened under sufficient tension to effect a slight overcorrection of the deformity Finally, to prevent slipping of the fascial strips, they are threaded on a fascia needle and woven into the parotid fascia, to which they are further fixed by means of sutures. To correct the sagging lower lid, a strip of fascia is passed from a preauricular incision through the substance of the eyelid along its margin, one end being fixed to the inner palpebral ligament and the other, after being tightened, to the temporal fascia (fig 630) Or fascial loops may be passed sub-

cutaneously from the forehead and secured to the lower lid at each canthus The remaining small wounds are closed with horsehair.

All tension on the implanted fascia is relieved by appropriately placed sterile strips of adhesive tape, and a pressure dressing is applied Support of the muscles is maintained for 2 weeks (26)

Blair (26) employs the following technic (fig 631). "The forehead—infra-orbital loop—may be inserted with the Reverdin needle along the base of the lower lid at the level of the infra-orbital border This can be done with the large Reverdin needle through a small supplementary incision opposite the middle of the infra-orbital border but it is better to use a large 'surgical' needle or a specially shaped old-fashioned 'perineal' needle on a handle

"To insert the upper loop, a five-millimetre incision is made well through the skin at a point external to the outer canthus, and another is made vertically, halfway through the orbicularis muscle just beyond the border of the philtrum on the opposite

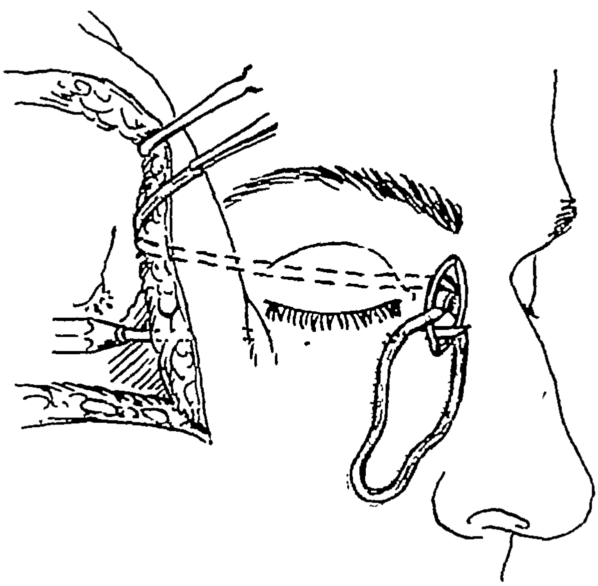


FIG 630 Suspension of lower lid in facial paralysis by use of fascial strip For details, see text

side The opposite side of the upper lip is fixed by grasping it with a Jacobs forceps which is left locked in place The unthreaded needle enters at the upper opening, traverses the cheek deeper than the skin, passes deep to the ala labial crease and traverses the lip equidistant from the skin and the mucosa It emerges through the cut on the other side of the philtrum, one end of a strand of fascia is locked in, and the needle withdrawn, the protruding lip-end of fascia being held with a forceps and protected from salivary contamination by damp gauze, the upper end of the strip is fixed to a damp gauze pad with an artery forceps, the pad itself having been previously fixed to the head towel—this to prevent accidental withdrawal of the strand The empty needle is then reinserted through the upper incision and traverses the cheek at a lower level than previously It passes close to the corner of the mouth within a few millimetres of the mucosa of the vermilion border to emerge through the original opening in the lip The other end of the same tendon is locked in and the needle withdrawn A Jacobs forceps is locked on the lower lip and, after making appropriate skin incisions, this same procedure is repeated in placing the fascia loop to the corner

of the mouth and in the lower lip In placing the lower lip loop, the upper bar of the loop must run close to the corner of the mouth and just within the vermilion, and the lower strand must be in the movable part of the lip not in the more fixed tissues of the chin

"The loops are all placed before any are tightened and fixed, and the Jacobs forceps remain locked in the upper and lower lips to assist in the over-correction in tightening and fixing the loops. The exact position of the lip and corner of the mouth loops may change in different cases but the close approximation of lower strand of the upper and upper strand of the lower lip loops to their respective vermilion borders is a matter of importance.

"The positions of the incisions of insertion will vary with the amount of sagging and will also be governed by the length of the tendon strands. Short strands can be spliced with split silk, but it is advantageous to use a single loop when practicable."

Gillies (86) attaches the ends of the fascia to the temporal muscle in the hope that its contraction will simulate facial expression He passes loops of fascia around the

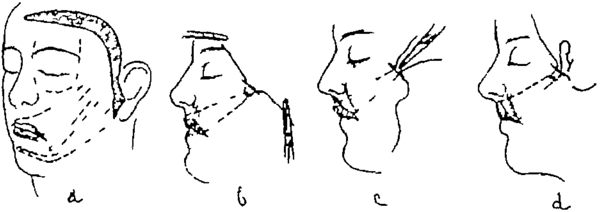


FIG. 631 Blair operation for fascial suspension of paralyzed facial muscles *a*, shaded area indicates skin to be removed. Dotted lines position of fascial loops *b* tension exerted on fascial loop to over correct deformity *c* knot held with forceps while being fixed to fascia with silk suture. *d* free end of suture fixed to surrounding tissue, and skin incision closed.

facial muscles at one or more of the following points (fig 632) (a) the center of the lower lip, (b) the corner of the mouth, (c) the centre of the upper lip, (d) round the palpebral fissure through tiny incisions in the situations named It is considered advisable to embrace the fibers of the non-paralyzed muscle in the upper and lower lip As the paralyzed half of each lip is much elongated, these loops are used to prevent this attenuation, in addition to acting as a general stay To effect this a loop must be passed from the corner of the mouth to the centre of each lip A convenient method of applying this particular support is to pass a figure-of-8 loop embracing both upper and lower paralysed muscles and fixing the same at the corner From the corner another loop or possibly a continuation of the same can be taken up to the point of fixation The fascial bands are attached to their fixed point by means of either silk or catgut sutures. The writer prefers catgut.

The muscles are reanimated by the attachment of the fascia lata loop to a temporal muscle flap "A flap of the temporal muscle is detached from its origin, turned downward and forward over the zygoma. The muscle belly is prepared and isolated, its nerve supply being kept intact. It is freed from the superficial layer of the temporal

fascia which is attached to the zygoma, but the deep layer which forms the sheath of the muscle is kept intact A band of fascia lata is now spread over the raw surface of the muscle and is sutured into this position The muscle belly is therefore encircled with a fascial sheath with a continuation of pseudo tendons of considerable length The fascia needle is now passed through the incision previously made at the corner of the mouth and when drawn down the muscle belly is pulled into the prezygomatic pocket which has been prepared for it It now remains to attach the pseudo tendon to the stay loop which encircles the paralyzed circumoral muscle at such a tension as will give a straight mouth "

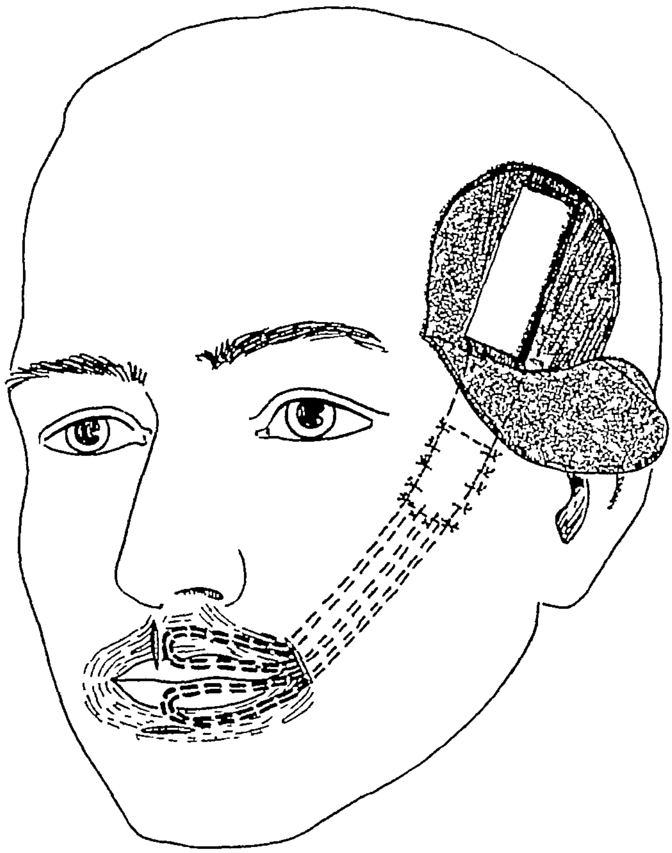


FIG 632 Fascial suspension of paralyzed facial muscles End of fascial loops attached to temporal muscle flap, so that contraction of muscle will simulate facial expression For details, see text (Gillies)

Kirschner (123) attaches the free ends of the fascia loop to the zygomatic arch, which he exposes through a horizontal incision just above its upper border (fig 633) Another skin incision is made at the angle of the mouth extending along the nasolabial fold An empty Blair needle is passed behind the zygoma posterior to the paralyzed facial muscles and is made to emerge through the nasolabial incision A strip of fascia 2 cm wide is caught in the eye of the needle, and the instrument is withdrawn The empty needle is again passed in a similar manner, this time in front of the zygoma The end of the fascia projecting from the incision is threaded into the eye and withdrawn The free ends are tightened until the deformity is overcome and are then sutured together around the zygoma The small residual wounds are closed by direct approximation, and a dressing is applied

Lodge carries the fascia subcutaneously in the form of a triangle, employing three small incisions, one at the corner of the mouth, a second at the inner canthus, and a third in the temporal region. The fascial strip is carried from the temporal incision to the corner of the mouth, embracing the paralyzed muscle, from there to the inner canthus along the lower lid, and out through the original incision. The single triangular fascial loop is tightened sufficiently to overcome the deformity and is fixed to the temporal fascia. The small skin wounds are closed in the usual manner.

(2) **Muscular Suspension.** The operation of muscular suspension is an attempt to reactivate the paralyzed facial muscles by the attachment to them of muscular

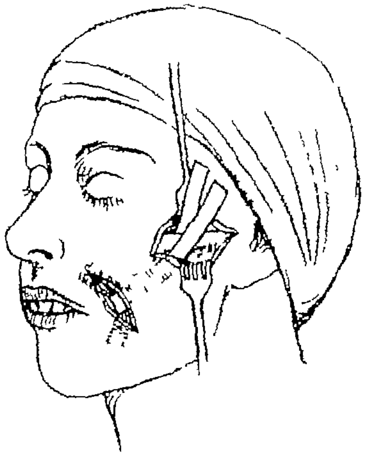
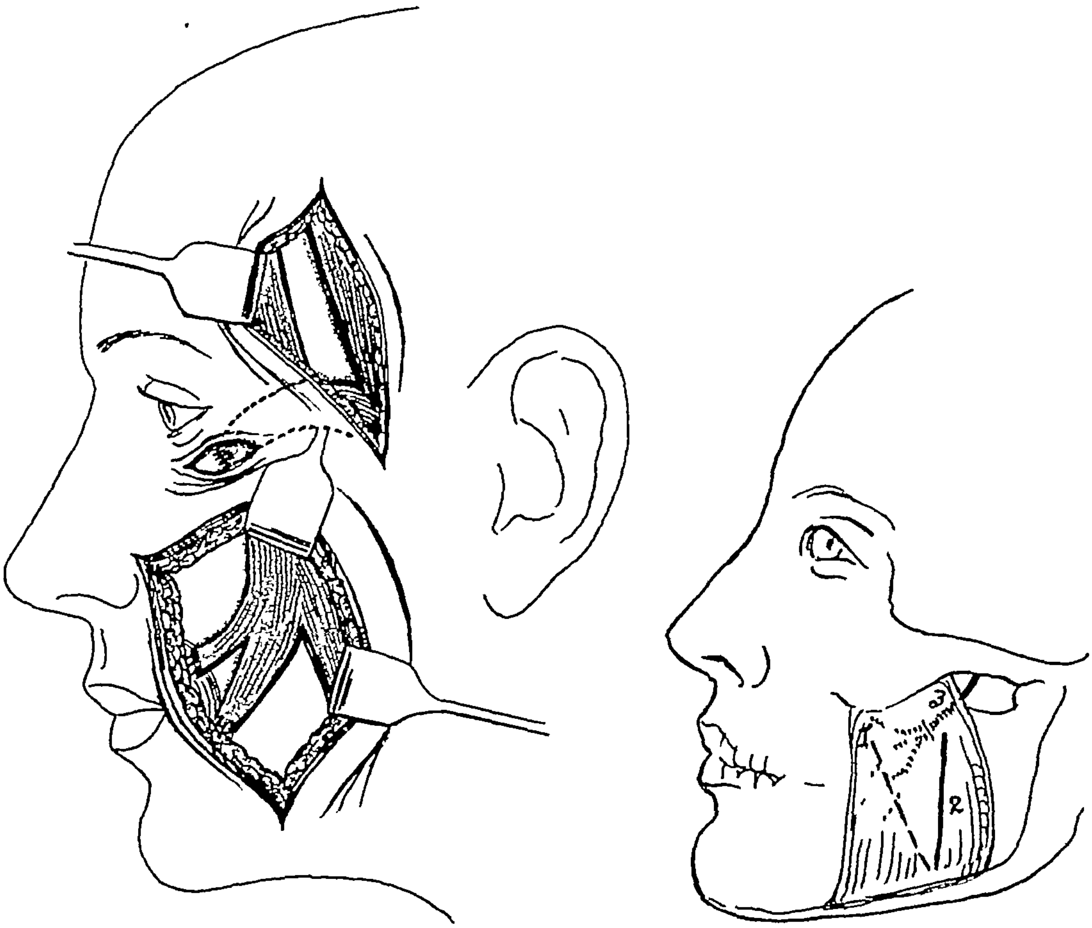


FIG. 633 Fascial suspension of paralyzed facial muscles by anchoring strips of fascia around zygomatic arch. (Kirschner)

flaps from contiguous unaffected muscles, on the assumption that the contraction of the healthy muscle will reanimate the paralyzed one. According to Rosenthal (202) the nerves of the implanted muscle unite with those of the paralyzed muscle to establish a new innervation.

The immediate results of this procedure are less satisfactory than those following a fascia lata suspension, since in the latter method the tension under which the fascial bands are fixed at the time of operation is sufficient to correct the deformity, whereas in muscular suspension in order to obtain the proper healing, the flap from the donor muscle must be sutured to the paralyzed muscle without tension, and therefore relief of the deformity does not begin until after healing and "neurotization" have taken place.

To raise the angle of the mouth, Lexer (142) employs flaps from the masseter muscle The technic is as follows (fig 634). An incision is made along the nasolabial fold, extending from the ala of the nose to a point 2 cm above the lower margin of the mandible The parotid gland is retracted to expose the masseter muscle, and two full thickness flaps 1 cm wide, pedicled above, are raised from the center of the muscle, care being taken to avoid injury to the masseter nerve which enters the muscle at its upper third (fig 634-b) One flap is sutured to the upper and the other to the lower part of the paralyzed orbicularis oris at the angle of the mouth Slight overcorrection is advisable,



a b

FIG 634 Suspension of paralyzed facial muscles by use of flaps taken from contiguous unaffected muscles *a*, angle of mouth elevated by flaps taken from masseter muscle Lower lid suspended with flap from temporal muscle (Lexer) *b*, line of incision for raising muscle flap *1*, incorrect incision, cutting masseteric nerve *3* *2*, correct incision, conserving nerve

to allow for subsequent stretching The overlying wound is then closed in the usual manner Brunner (41) operated similarly but eliminated the external incision by carrying the masseter muscle flap to the angle of the mouth through a buccal incision

Lexer (142) elevated the paralyzed eyelid with a flap from the temporal muscle, as follows A vertical incision is made in the temporal region inside the hair line, and a smaller secondary incision is made at the inner canthus A muscle and fascia flap with its pedicle below is then raised from the anterior margin of the temporal muscle The flap is divided into two bundles, and with the aid of two silk sutures these are carried subcutaneously through previously prepared channels in the upper and lower

eyelid to meet at the inner canthus. The sutures are left long and used to fix the flaps to the canthal ligament and the periosteum. When the temporal muscle contracts, the eyelids are squeezed together by the encircling flaps.

If a sternomastoid muscle flap is to be used (115), the muscle is exposed through an incision beginning at the mastoid process and extending along the anterior border of the muscle to a point just below the angle of the mandible (fig 635) Another incision is made at the angle of the mouth to expose the paralyzed muscle, and the two skin incisions are connected by a subcutaneous tunnel. A sternomastoid muscle flap is then raised with its pedicle above, care being taken to preserve the blood and nerve

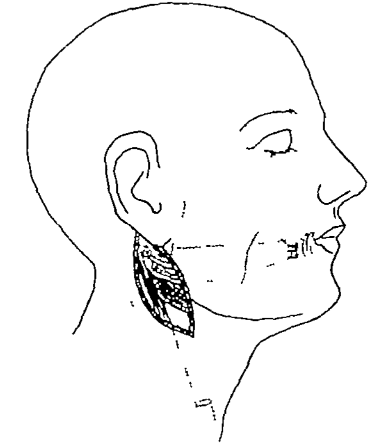


FIG. 635 Suspension of paralyzed facial muscles by use of flap taken from sternomastoid muscle. Sternomastoid exposed through incision extending from mastoid process to angle of mandible. Paralyzed orbicularis oris exposed through incision at angle of mouth. Tissues between 2 incisions undermined, to form subcutaneous canal. Flap of sternomastoid, pedicled above, passed through canal and anchored to paralyzed muscle. (Gomoiu Jianu)

supply, and is carried through the previously prepared channel and anchored to the paralyzed orbicularis oris. Although this procedure relieves the deformity, it causes distressing associated movements and a rotation of the head to the opposite side whenever the shoulder or neck is moved.

Halle (95) operates in a somewhat different manner, as follows (fig 636) Under local anesthesia a longitudinal preauricular incision is made similar to that employed in the face-lift operation (p 1350) Another incision is made in the lower lid as for the removal of pouches (p 1358) Through the preauricular incision the temporal, epicranius and orbicularis oculi muscles are exposed. From the center of the temporal muscle a flap is raised, with its pedicle at the coronoid process. This flap in turn is

subdivided into two parts which are sewn to the orbicularis muscle of the upper and lower lids respectively To suspend the angle of the mouth, the masseter muscle is used An incision is made under the mandible, care being taken to avoid injury to

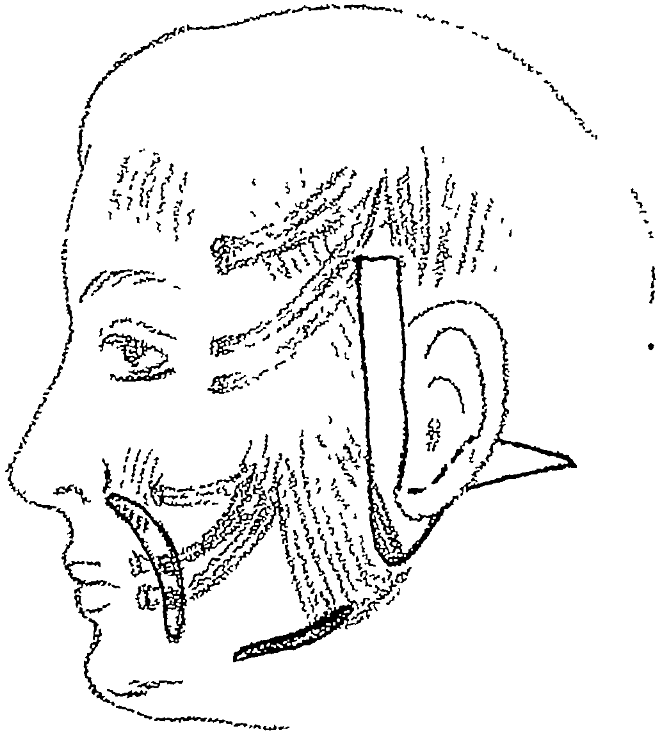


FIG 636 Muscular suspension of paralyzed facial muscles Incisions made in preauricular region, lower lid, nasolabial groove, and below mandible Through preauricular incision, temporal muscle flap pedicled at coronoid process raised Muscle flap divided into 2 parts and attached to orbicularis oculi of upper and lower lids Though incision below mandible, 3 flaps, pedicled above, cut from masseter muscle and attached to paralyzed levator anguli oris and orbicularis oris, exposed through nasolabial incision For details, see text. (Halle)

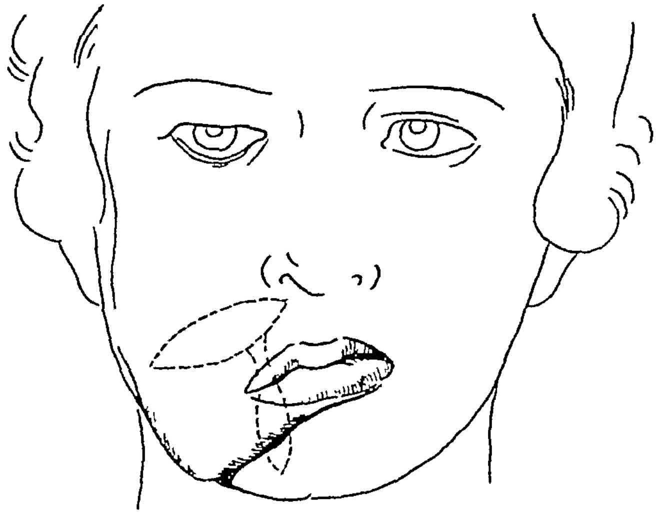


FIG 637 Joseph operation for correction of facial distortion, by excision of variously shaped sections of skin and subcutaneous tissue

the facial artery. The masseter is exposed close to its origin, and two flaps pedicled above, are cut from it, one to be attached to the paralyzed levator anguli oris and the other, after division into two equal parts, to be fitted into the upper and lower

angles of the orbicularis oris. An incision is now made in the nasolabial groove The orbicularis oris is exposed, the skin undermined to the masseter, and the masseter muscle flaps previously separated are joined to it. The wounds in the lower lid, the preauricular region, and the angle of the mouth are sutured drainage being provided for in the latter wound Finally, a light compression bandage is applied.

Gersuny (81) transferred a pedicle of the orbicularis oris from the non paralyzed to the paralyzed side.

(3) **Skin Excision.** Attempts have been made to correct facial paralysis by the removal of variously shaped sections of skin and subcutaneous tissue and suturing the opposing margins under sufficient tension to overcome the deformity (fig 637) The technic of this procedure is detailed in Chapter XIX. The results are only temporary, as in time the scar stretches and the defect reappears. Nevertheless, the operation frequently proves beneficial when used in conjunction with other measures.

Schmerz (207) excised a section of skin from the nasolabial fold, in order to raise the angle of the mouth. Pickerill (187), in an effort to eliminate the external scar, removed an appropriately sized section of tissue from the buccal side.

Alleviation of the deformity resulting from facial paralysis has also been attempted by the use of *prostheses*, and there are many types available. Most of the appliances are designed to be fastened to the teeth and are equipped with various attachments for the raising of the angle of the mouth and cheek. On the whole, these devices are unsatisfactory and are soon discarded by the patient. They find their greatest usefulness in furnishing support to the paralyzed muscles during the period of nerve regeneration.

FACIES SCAPHOIDEA (DISH FACE)

Facies scaphoidea is a malformation characterized by a recession of the middle part of the face and a relative protrusion of the forehead, cheek, and mandible The deformity is usually congenital from a deficient development of the maxilla, especially that portion of it which forms the foundation of the nose, or it may follow operations for the correction of a cleft lip and palate in which the premaxilla has been removed or has been displaced too far backward. Occasionally, it is caused by trauma wherein the bones of the nasal, frontal, and ethmoid compound are impacted backward. The condition can be diagnosed at a glance. The forehead is relatively prominent and the middle of the face is recessed, especially in the region of the pyriform opening The dental arcade is narrowed and shortened, and there is malocclusion of the teeth, the lower incisors projecting beyond the upper when the mouth is closed. The nose displays characteristic features while the osseous portion projects normally, the lower half is held back by its attachment to the recessed and underdeveloped *maxilla*, a hump appearing at the junction of the protruding and depressed segments. The septum and mucous membrane are shortened in an anteroposterior direction, the flare of the alae is deficient, and the apertures are narrowed, giving the lower part of the nose a pinched appearance. Due to the underdevelopment of the alveolar process of the maxilla, the upper lip is sunken and because of an insufficient growth of the maxilla vertically, the lip appears to be abnormally long and has a tendency to turn into the mouth. The contrast between the normal mandible and the deficient maxilla produces a condition resembling prognathism.

Treatment Irrespective of the cause underlying the condition, each element of the deformity requires individual correction. Generally speaking, the basis of treatment consists in building out the deficient maxillary foundation and lengthening the shortened mucous membrane, so that the retracted soft tissues may be brought forward

In young patients orthodontic measures designed to carry the teeth forward and outward will do much to overcome the deformity, but the treatment is slow and expensive, requiring a period of years In older individuals correction can be accomplished only through surgical intervention

In the traumatic type of the condition it is more expedient to camouflage the deformity by the subcutaneous implantation of a graft or by the use of a prosthesis, rather than attempt to reposition the bones The dorsum of the nose is built up with a cartilage implant (p 700), and the upper lip and base of the nose are repositioned by separating the soft tissues from the maxilla, skin-grafting the raw area (p 1187),

FIG 638 Coughlin operation for dish face *a*, incision *b*, soft tissues retracted, and periosteum elevated around pyriform opening Nasal spine cut through, and mucoperichondrium of nasal floor and septum elevated *c*, bone-cartilage graft inserted into prepared cavity For details, see text (Surg Gynec & Obst., Vol 40)

and introducing into the skin-lined cavity a prosthesis carrying a flange designed to bring the nose and lip forward

When the condition is congenital, it is best to build out the underdeveloped jaw with a cartilage implant The nose is carried forward by a lengthening of the columella, and the bridge and tip are supported by means of a hinged cartilage graft (p 703).

Coughlin (52) corrects the dish face deformity as follows (fig 638): The base of the nose is separated from the face by an incision beginning in the nasolabial groove, passing into the nostril along the floor of the nose, across the columella, into the floor of the opposite nostril, and terminating in the opposite nasolabial groove The soft parts, together with the periosteum, are elevated from the maxilla until the pyriform opening is exposed Then the nasal process is cut through, and the mucoperichondrium of the nasal floor and lower half of the septum is raised for about 2 cm from the nasal spine. The septum is divided by an incision which begins at the nasal spine and extends upward and backward for approximately 2 cm A bone-cartilage transplant consisting of 1 5 cm of the fifth rib and 3 cm of its cartilage is removed and split

sideways. A hole is drilled through the cartilaginous end of each piece A strand of #1 20-day catgut is run through the hole of one piece, and the graft is inserted, bony end downward, into the prepared osseous cavity its medullary surface being directed toward the denuded upper jaw The second piece is now threaded on the catgut and inserted on the other side. Both pieces are adjusted around the pyriform opening, and the cartilaginous ends are drawn together by tying the ends of the catgut suture. Finally, the soft parts are replaced and sutured. The operation may be supplemented by the implantation of a hinged cartilage graft to raise the nasal dorsum. (The external scar can be eliminated by exposing the pyriform process through an incision in the upper buccal sulcus.)

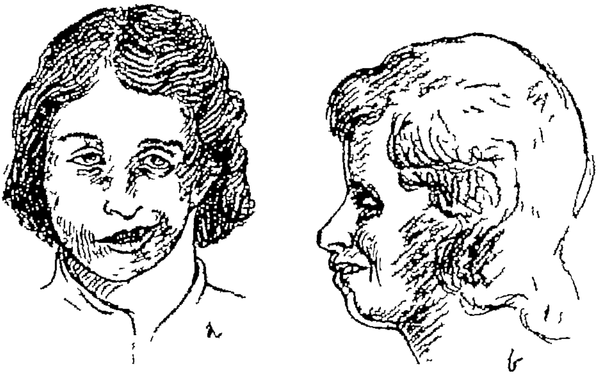


FIG. 639 Frontal and profile views of facial hemiatrophy Note that two sides of countenance seem to belong to different individuals.

PROGRESSIVE FACIAL HEMIATROPHY

Facial hemiatrophy is a rare malady originally described by Romberg (199) in 1846 It is a disease of early life, occurring as a rule in the second decade (5) although it occasionally appears during the first year and in advanced age. Heredity does not seem to play a part in its production (157) When the condition is encountered in the first year of life, it is usually attributed to birth trauma. The underlying cause of this peculiar dystrophy is obscure, and a great many theories have been advanced. The etiologic factors thought to be responsible are (1) traumatisms about the head and neck, (2) damage to the trigeminal and parasympathetic fibers, (3) injury or compression of the cervical sympathetics (5), (4) cephalic trophoneurosis due to involvement of the gray matter around the aqueduct of Sylvius and the fourth ventricle (224), (5) endocrine disturbances, (6) toxemia following infectious diseases, and (7) a manifestation of scleroderma.

The atrophic process, as a rule, involves all the structures of the face, including skin,

subcutaneous fat, muscle, bone, and cartilage, although not infrequently a layer of tissue escapes (fig 639) It usually begins along the distribution of a branch of the fifth cranial nerve and spreads gradually until the entire side of the face is affected, so that the two sides of the countenance seem to belong to different individuals Occasionally, the condition is arrested at some stage of its development, manifesting itself as a localized atrophy, or it may spread to the neck, thorax, or the entire half of the body (71)

Owing to the indefinite pathogenesis, no satisfactory treatment for this condition has been evolved Periarterial sympathectomy has been advocated by Cassirer (48) In the case of localized dystrophy the deformity may be somewhat relieved by the use of subcutaneous transplants of fascia lata and cartilage.

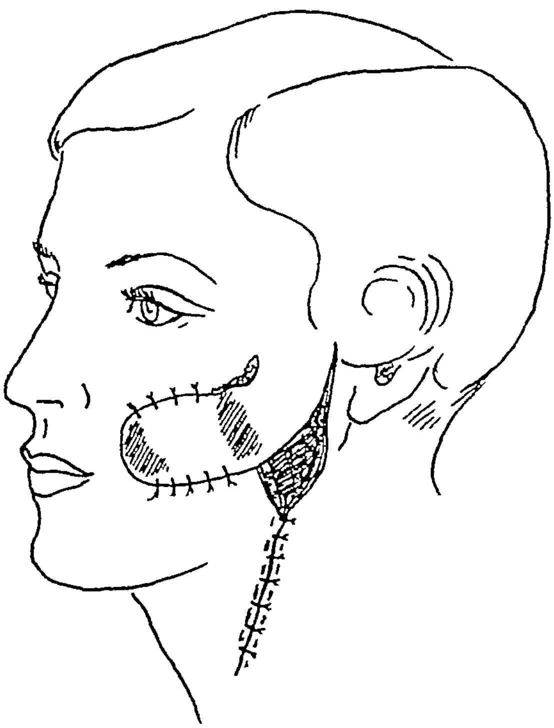


FIG 640 Replacement of cheek skin with neck flap

RECONSTRUCTIVE SURGERY OF MAXILLOFACIAL REGION

Reconstructive procedures of the maxillofacial region contemplate the replacement of skin, supporting framework, and mucous membrane, either singly or in combination As in other parts of the body, repair should be delayed until all danger of infection has subsided and the nutrition of the tissues has been improved to the utmost by means of physiotherapy. The mouth must be placed in the best possible condition, decayed teeth should be extracted, healthy teeth scaled, and the parts frequently sprayed with some antiseptic solution

Repair Following Skin Loss

Minor skin losses, such as those following the removal of linear scars, can be repaired by direct approximation of the wound margins (p 69) In the case of more extensive losses, where this procedure would involve too much tension, new tissue must be

supplied, and here a decision must be made as to the most appropriate source of such material The problem is to furnish skin which will reproduce as accurately as possible the thickness, color, texture, elasticity, and hairiness of the destroyed malar tissue and blend with the parts that will ultimately surround it. The skin nearest the defect is obviously most suitable for the purpose, but its desirability in this regard is often outweighed by the secondary scar thus created and the limited quantity of material available

If the denuded area is well nourished a graft may be employed, the most appropriate type being a full thickness skin transplant taken from the upper eyelid or postauricular region, in men such grafts may also be secured from a hairy region, such as the scalp or pubes. But in the absence of a good nourishing base flaps must be resorted to

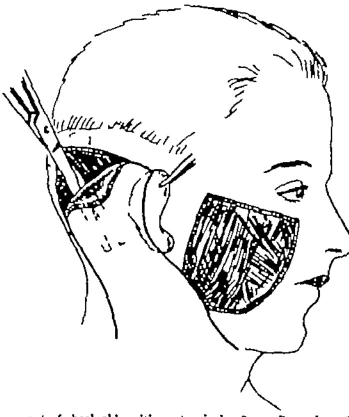
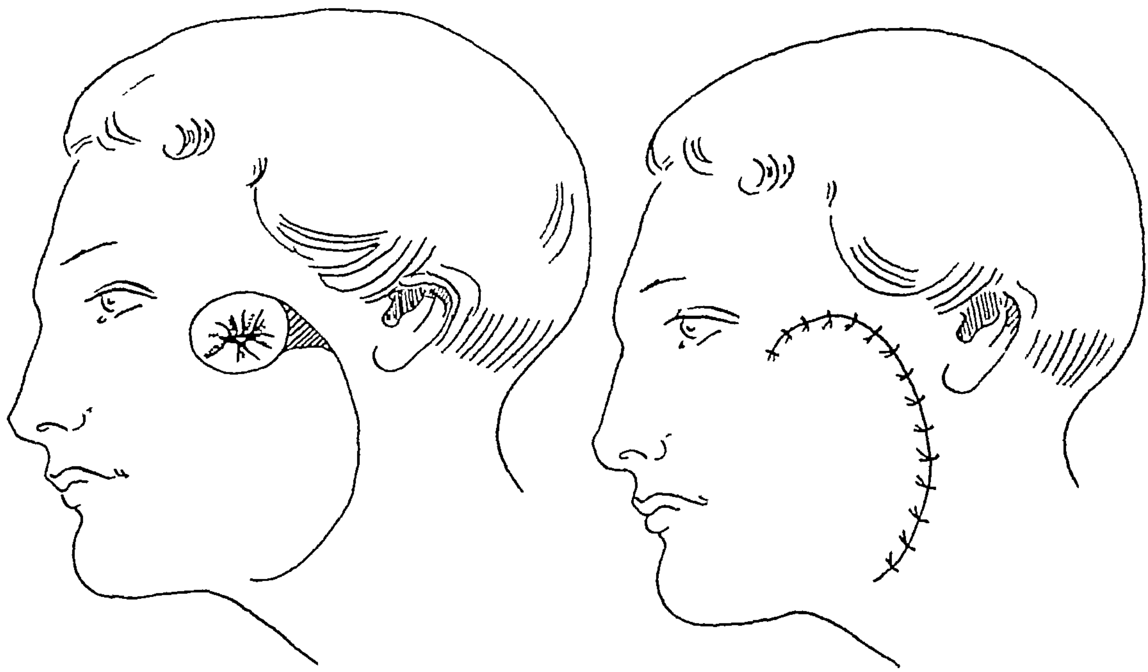


FIG. 641. Replacement of cheek skin with postauricular flap. Secondary defect skin-grafted.

If the size of the defect permits, advancing or rotating flaps secured from the vicinity best subserve the purpose These flaps furnish an excellent match for the lost tissues, and because of the good vascularity of the cheek, they can be utilized with little danger of necrosis (figs 640–641)

The rotation cheek flap advocated by Esser (64) and von Imre (111) is very effectual, inasmuch as there is no pedicle to be cut and the repair is concluded after the sutures have been passed. Its chief drawbacks are the long scar resulting from the necessarily long incision and the likelihood of profuse hemorrhage from the extensive undermining The location of the incision is determined by the situation and size of the loss, but generally it begins at the upper edge of the defect, circumscribes a broken arc, and runs downward along the front of the ear (figs. 642–645) If more mobilization is necessary it is carried into the neck where another arc is formed, the rising arm

of the lower arc ending approximately at the medial point of the original one During the outlining of the flap care must be taken that the incision is kept above the level of the facial nerve The flap is undermined for a distance sufficient only to permit of



a b

FIG 642 Repair of cheek defect by swinging advancement flap *a*, pathologic tissue requiring removal circumscribed by incision Flap outlined by arched incision Shaded area indicates tissue to be removed, to facilitate rotation *b*, scar removed Flap undermined, rotated upward, and sutured n place (Blaskovics-von Imre) (See Figure 144)

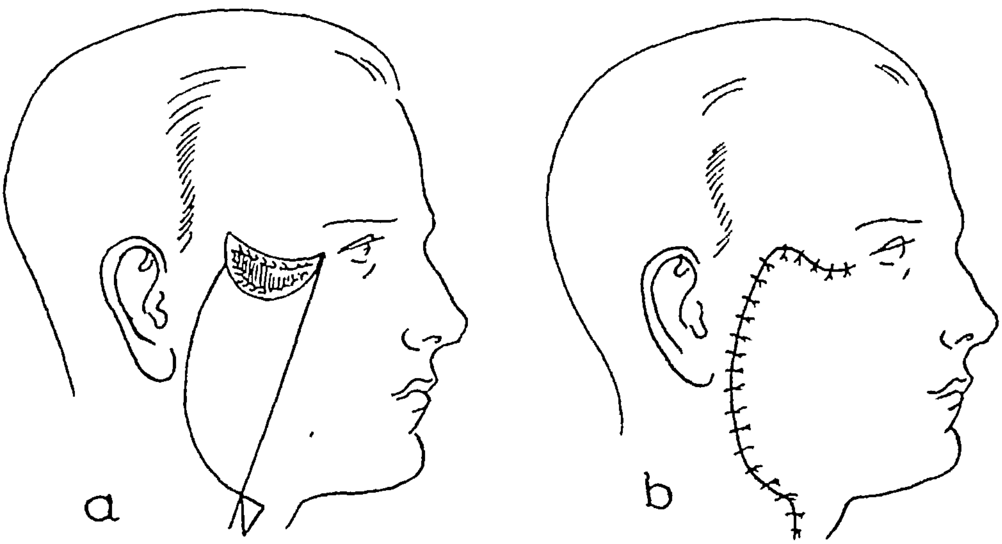
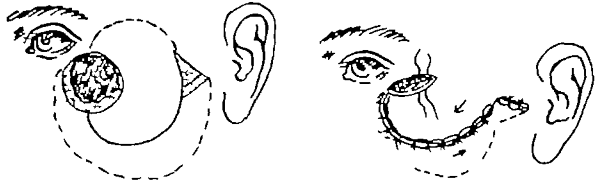


FIG 643 Repair of cheek defect by swinging advancement flap *a*, arched incision carried from outer angle of defect into neck Triangle of skin to be removed outlined at lower end of incision, to facilitate rotation Dotted line indicates amount of undermining, straight line, relation of triangle to defect *b*, flap mobilized, swung upward, and fixed by sutures (Blaskovics-von Imre) (See Figure 144)

its rotation into the defect under considerable tension, since excessive undermining tends to jeopardize its nutrition, separates the skin from the muscles of expression, and endangers the facial nerve and the parotid duct When hemostasis has been secured,

the mobilized flap is rotated into the defect. Deep sutures of catgut ~~or silk~~ are passed to relieve tension, and the skin margins are carefully approximated in their new relationships from above down with the finest silk

When the immediately contiguous tissues are unsuitable for use, the next choice in the case of women is the forehead flap, since the residual scar can be concealed by the coiffure, in men a flap taken from the scalp (87) is preferable as it furnishes hair to hide the cicatrix in both the donor and recipient areas.



a b

Fig. 644. Repair of cheek defect by swinging advancement flap *a*, flap outlined by arched incision extending from lower margin of defect. Triangle of skin removed at end of incision, to facilitate rotation. Dotted line indicates amount of undermining. *b* flap mobilized, swung into defect, and sutured in place. (Blaskovics-von Imre) (See Figure 144.)

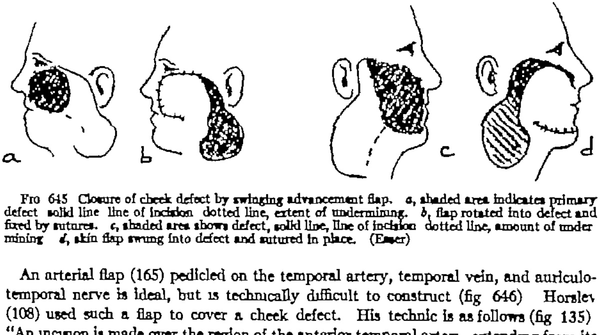


Fig 645 Closure of cheek defect by swinging advancement flap. *a*, shaded area indicates primary defect solid line line of incision dotted line, extent of undermining. *b*, flap rotated into defect and fixed by sutures. *c*, shaded area shows defect, solid line, line of incision dotted line, amount of undermining *d*, skin flap swung into defect and sutured in place. (Esser)

An arterial flap (165) pedicled on the temporal artery, temporal vein, and auriculotemporal nerve is ideal, but is technically difficult to construct (fig 646) Horsley (108) used such a flap to cover a cheek defect. His technic is as follows (fig 135) "An incision is made over the region of the anterior temporal artery, extending from its origin to the point at which the artery enters the proposed flap This incision should be straight, no matter what the course of the artery Great care is taken not to injure the artery and not to grasp it with forceps. It can be easily handled by picking up the tissue around it with delicate thumb forceps. Considerable tissue is included with the artery in order not only to avoid injury to the artery, but also to preserve its nerve supply After the artery has been freed, the flap is cut and placed in position. This gives an idea where the artery shall be buried The flap is covered with cloths wrung

out of warm salt solution and an incision for burying the artery is made just through the skin The margins of this incision are undermined freely, but not too deeply In this way the branches of the facial nerve are not injured. The flap is placed in position and fastened with a few sutures It should not be sutured too tightly, because the flap has too much nutrition, and unless there is some point where the excess of blood can ooze out for the first day or two, the tension in the flap from the arterial pressure may be so great as to cause partial necrosis This, in fact, is the chief danger, not too little but too much blood supply If it is necessary to have an epithelial lining, a flap may be turned up from the neck and sutured with the skin side toward the cavity of the

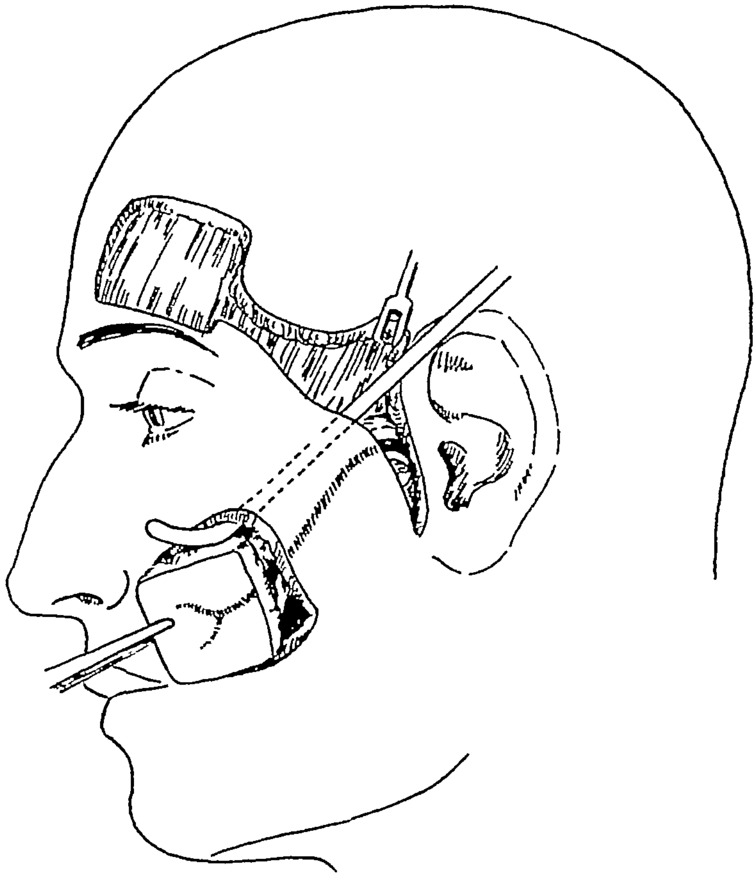


FIG 646 Closure of cheek defect by flap taken from forehead and pedicled on temporal artery, vein, and nerve Arterial pedicle dissected out Forehead flap raised, passed beneath bridge of cheek tissue, and implanted into defect (Monks) (For the replacement of full thickness cheek losses, the under surface of such a flap may be skin-grafted, to provide lining)

mouth before the anterior temporal artery is transplanted or mucous membrane from the tongue can be used, as suggested by Willard B

If the surrounding skin is deficient in quantity ... scars, or if the secondary defect necessitated by its use ... must be transferred from a distance Should a flap be ... the most appropriate donor sites are the transverse cervical, suprascapular, and bicipital regions.

REPAIR FOLLOW... OUS M

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that separation of the jaws becomes impossible, speech and mastication being thus interfered with. While theoretically the replacement of mucous membrane with a similar tissue is the ideal procedure, the quantity of mucosa available for this purpose is limited. Therefore, in all but minor defects hairless skin must be substituted.

Small losses may be replaced with flaps of contiguous mucous membrane, provided the secondary defect thus created can be closed directly without tension. Mucosal grafts may also be used for the purpose, but in the oral region they are not as satisfactory as in other parts of the body.

In cases of extensive destruction, Esser's (64) inlay method (p. 142) is the most practical because of its simplicity of application and its uniformly good results. The technic is as follows. An incision is made in the skin of the cheek overlying the buccal scar, and a bed is prepared by undermining the tissues. After complete hemostasis has been secured, a piece of softened stent is introduced into the cavity and an impression made of the defect. The mold is then removed, covered with a thin razor graft from some hairless part of the body, reinserted, and the skin incision above it closed. After

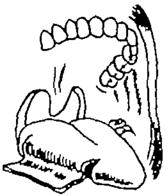

FIG. 641. Repair of buccal mucosa in edentulous jaw by flap taken from floor of mouth. Mucous membrane flap pedicled on lateral margin of tongue raised. Free extremity of flap sutured into upper margin of defect. After vascularization donor pedicle severed, and remaining end of flap sutured into lower margin of defect. (Lexer)

10 days the scar on the mucous membrane is excised and the mold removed through the resultant wound, an epithelized cavity communicating with the mouth remaining.

Pickerill (186) and Waldron, in an effort to avoid an external scar, introduced the graft-covered mold by way of the mouth, thus. The scar on the buccal mucosa is removed and an appropriately shaped piece of stent clothed with a thin razor graft is pressed into the raw area and held in place either with loops of silkworm-gut passed through the full thickness of the cheek and tied externally over a gauze pad, or by the attachment of the compound to a tray affixed to metal-cap splints on the teeth. The jaws are immobilized by interdental wiring (p. 1208) for 10 days. At the end of this period the mold is removed, and the area will be found epithelized. Such grafts "take" well despite the septic nature of the oral cavity. As a precaution against subsequent contraction of the epithelized surface, the mold is replaced with one of gutta percha or vulcanite and worn for 2 or 3 months or longer, being removed daily for purposes of cleansing. In the case of patients with edentulous jaws the mold may be made to form a part of the artificial denture.

For the replacement of mucous membrane losses involving a considerable quantity of submucous tissue without destruction of the skin, a skin flap may be employed to

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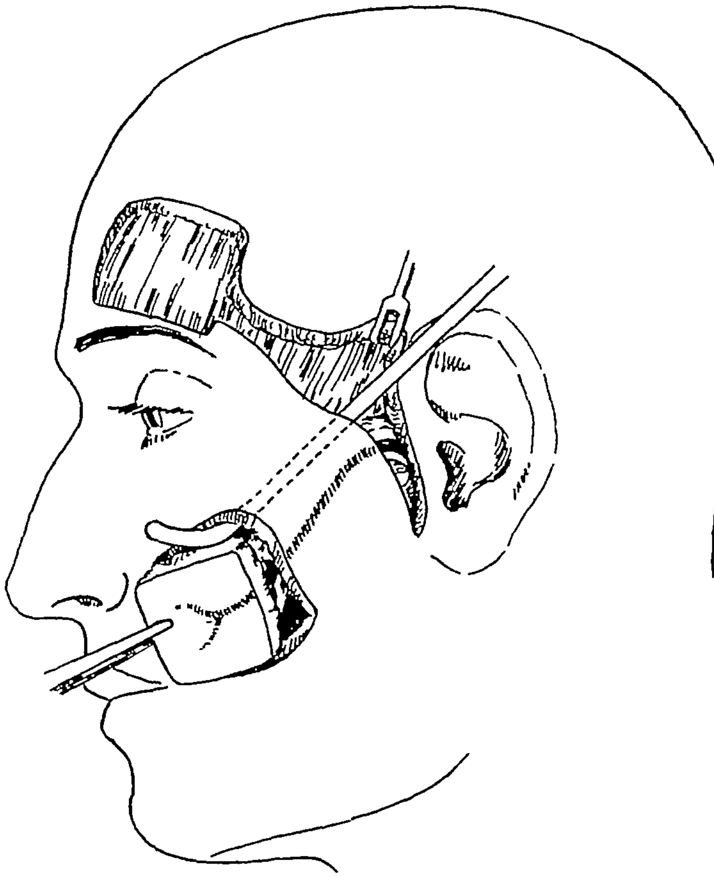

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If the surrounding skin is deficient in quantity or unusable because of scars, or if the secondary defect necessitated by its use would be objectionable, skin must be transferred from a distance Should a flap be employed to replace the loss, the most appropriate donor sites are the transverse cervical, vertical cervical, acromiopectoral, suprascapular, and bicipital regions

Repair Following Mucous Membrane Loss

Because the oral mucosa normally rests on a bed of areolar tissue capable of great contraction, a loss of this membrane frequently results in such extensive distortion

that separation of the jaws becomes impossible, speech and mastication being thus interfered with. While theoretically the replacement of mucous membrane with a similar tissue is the ideal procedure, the quantity of mucosa available for this purpose is limited. Therefore, in all but minor defects hairless skin must be substituted.

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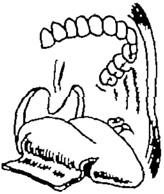

Fig. 647 Repair of buccal mucosa in edentulous jaw by flap taken from floor of mouth. Mucous membrane flap pedicled on lateral margin of tongue raised. Free extremity of flap sutured into upper margin of defect. After vascularization donor pedicle severed and remaining end of flap sutured into lower margin of defect. (Lexer)

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advantage The flap is introduced either by way of the mouth or through an incision below the margin of the mandible Gersuny (80) repaired such a defect with a triangular flap of skin taken from the neck and pedicled on the periosteum of the mandible (fig 853) The flap was turned skin side in and joined to the remaining mucous membrane The secondary wound in the neck was closed by direct approximation The obvious objections to this method are the precarious viability of the flap, owing to the interference with its blood supply and the extensive torsion on the pedicle, and, in the case of men, its hair-bearing quality

To replace a mucosal loss in a patient with an edentulous jaw, Lexer (141) employed a rectangular flap of mucous membrane taken from the floor of the mouth, with its pedicle on the lateral margin of the tongue (fig 647) The free extremity of the flap was sutured into the upper margin of the defect, and after vascularization the pedicle was severed and the remainder of the flap sutured into the lower margin

Bartlett (18) corrected a similar deformity by splitting the lateral margin of the tongue longitudinally and suturing the flaps thus formed into the defect After vascularization had taken place, he cut the pedicles and in this way freed the tongue (fig 648)

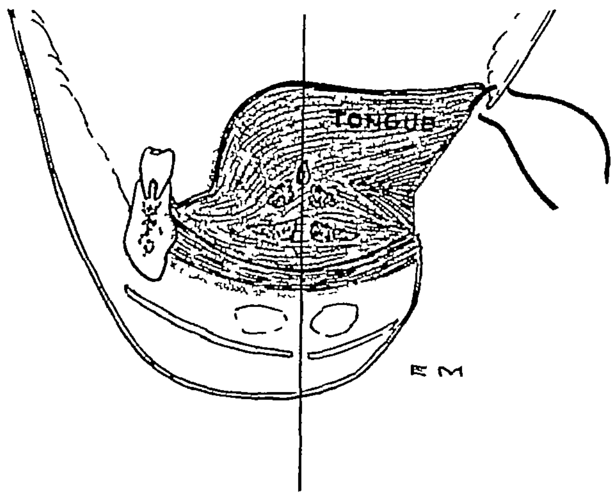

FIG 648 Repair of mucosal defect of cheek by tongue flap Sectional view through mouth, at level of first molar Red line indicates margin of tongue split parallel with floor of mouth *Flaps thus formed sutured into margins of defect.* After vascularization, tongue separated from cheek (Bartlett)

REPAIR FOLLOWING -OSS OF SUPPORT

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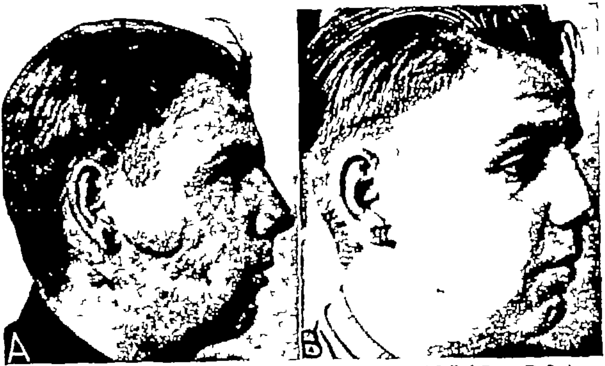

FIG 649 Depressed cheek scar built out with fascia lata graft. (Medical Dept., U S Army Vol. XI)

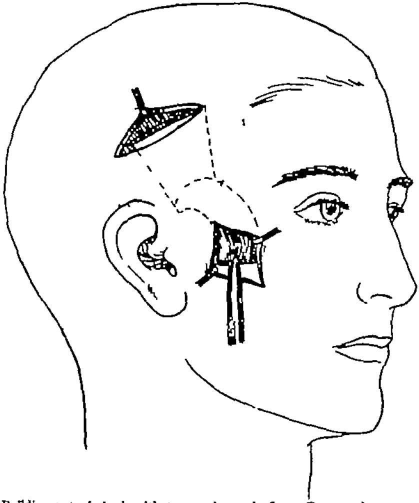

FIG 650 Building out of cheek with temporal muscle flap. Depressed scar excised. Temporal muscle exposed through incision within hair line. Flap of muscle and overlying fascia detached down to coronoid process. Free end of flap drawn through subcutaneous tunnel and anchored to periosteum of maxilla

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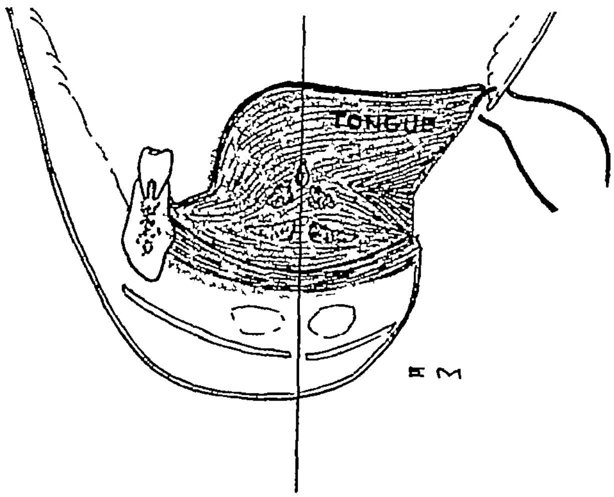

FIG 648 Repair of mucosal defect of cheek by tongue flap Sectional view through mouth, at level of first molar Red line indicates margin of tongue split parallel with floor of mouth Flaps thus formed sutured into margins of defect After vascularization, tongue separated from cheek (Bartlett)

Repair Following Loss of Support

When the supporting structures of the cheek have been lost, they may be replaced with fascia grafts, temporal muscle flaps, or transplants of bone or cartilage, the choice depending upon the nature of the tissue destroyed A small depression resulting from a loss of soft tissue may be built out with a fat flap rotated into the area from the immediate neighborhood, or the cavity may be obliterated with a graft of fascia lata (fig 649) The latter material is particularly suitable for the purpose, as it "takes" well and resists absorption Frequently, a temporal muscle flap can also be used to advantage (fig 650): After excision of the scar tissue and a general rearrangement of the remaining skin, the temporal muscle is exposed through an incision in the hair line The anterior third to half of the muscle, together with its overlying fascia, is detached from its origin and separated as far down as the coronoid process of the mandible The

been pared Defects too extensive for such closure require a thick flap carrying epithelium on both its surfaces The lining is provided either by skin-grafting of the under surface of the proposed flap, by a doubling of the flap on itself, or by the apposition of two flaps, raw surface to raw surface When feasible, the first method should be chosen, since the other two types of flaps mentioned, even after the removal of the subcutaneous fat, are bulky cumbersome, and unsightly Flaps from the vicinity are preferable for reasons already given (p 1039) The flaps previously described as suitable for the replacement of skin losses of the cheek are also applicable in the case of total losses of soft parts, provided lining has been supplied by skin-grafting the under surface of the flap prior to its rotation into the wound For instance, in women

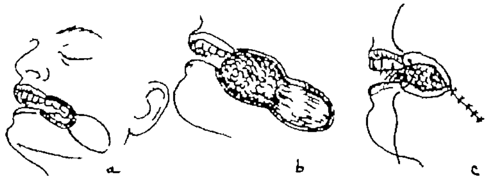

FIG 652. Repair of full thickness cheek defect in vicinity of oral commissure. a, skin flap outlined with pedicle on margin of defect. b flap turned, skin side in, and sutured to edges of defect, to replace lining. c, margins of wound undermined and approximated. (Kraske)

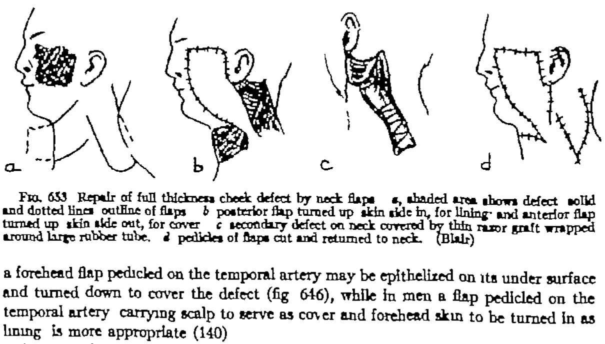

FIG. 653 Repair of full thickness cheek defect by neck flaps a, shaded area shows defect solid and dotted lines outline of flaps b posterior flap turned up skin side in, for lining and anterior flap turned up skin side out, for cover c secondary defect on neck covered by thin razor graft wrapped around large rubber tube. d pedicles of flaps cut and returned to neck. (Blair)

a forehead flap pedicled on the temporal artery may be epithelized on its under surface and turned down to cover the defect (fig 646), while in men a flap pedicled on the temporal artery carrying scalp to serve as cover and forehead skin to be turned in as lining is more appropriate (140)

A flap of skin pedicled on the margin of the defect may be turned into the mouth, skin side in, to furnish lining The skin margins are then undermined and sutured together (129) to cover the raw surface (fig 652) The tendency on the part of the inturned flap to slough and the secondary distortion are obvious objections to this procedure.

Blair (25) repaired a defect involving a full thickness cheek loss by means of an anterior and a posterior neck flap (fig 653) The posterior flap was used to supply

free extremity of the muscular flap is then passed through a subcutaneous tunnel and anchored to the periosteum on the upper part of the maxilla by means of a few sutures (87)

When the loss involves the lower margin of the orbit and support must be furnished to the eyeball, a portion of bone cut from the curve of a rib or the ilium, or a properly fashioned cartilage graft is most suitable While bone forms an organic union with the surrounding bone and furnishes better support, some surgeons favor cartilage, on the grounds that it is more easily shaped A plaster impression of the defect is made, and the deformity is built up in wax From this wax mold a lead model is constructed to be used as a pattern for the graft An incision is made over the defect, or if a scar exists, its excision will furnish a convenient approach All cicatricial tissue,

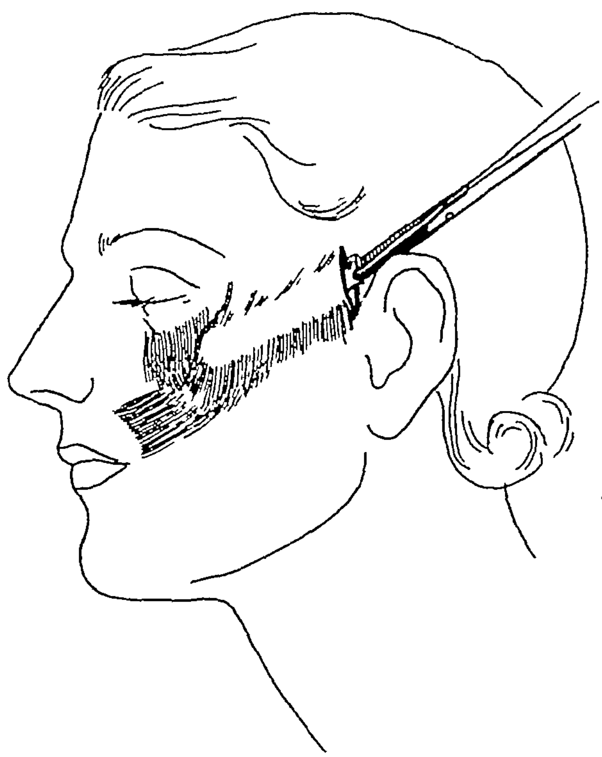

FIG 651 Restoration of lower margin of orbit with shaped cartilage or bone graft For details, see text.

is removed and the bed prepared The transplant of cartilage or bone is procured shaped to pattern, morticed into the defect, and secured in place with catgut sutures passed through the periosteum of the adjacent bone and the membrane covering the graft (fig 651) The skin wound is closed and a pressure dressing applied The jaws are immobilized until the graft has become established in its new location, the patient being fed temporarily through a nasal tube Figi (70) anchors the graft by driving a metal peg through the skin, the graft, and the underlying bone

Repair Following Full Thickness Cheek Loss

The methods employed for the replacement of full thickness losses of malar tissue vary greatly, depending upon the situation and size of the defect Minor defects can frequently be closed by approximation of the tissues in layers after the margins have

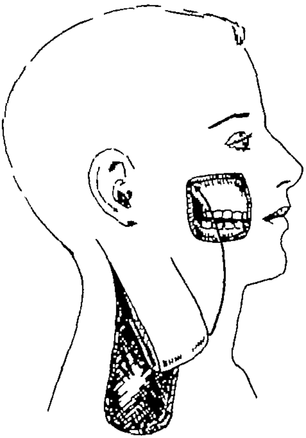

Fig. 656 Repair of full thickness cheek defect by folded-over neck flap (Blair)

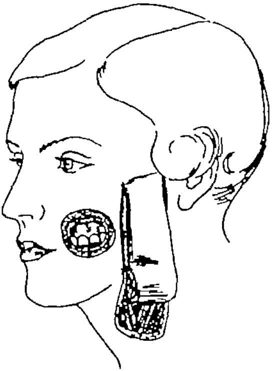

Fig. 657 Repair of full thickness cheek defect by folded-over cheek-neck flap (Czerny)

Israel (112) repaired a full thickness defect of the cheek in three stages, as follows (fig 655) In the first stage a long vertical flap of skin and subcutaneous tissue, its

lining and the anterior flap to furnish cover The residuary wound on the neck be then covered with a razor graft wrapped around a large rubber tube

A neck flap pedicled below the mandible may be employed to replace the mucous membrane, and a scalp flap pedicled on the temporal artery may be turned down to

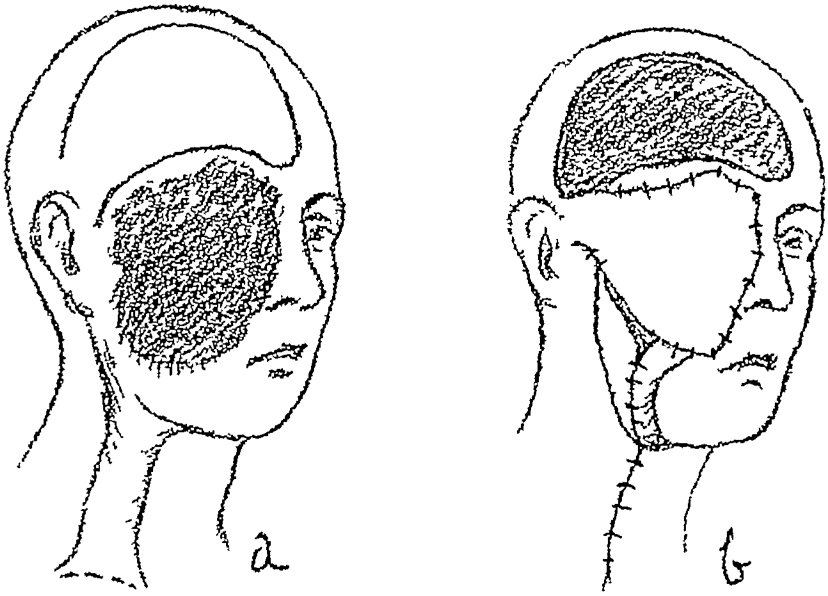

Fig 654. Repair of cheek-orbit defect *a*, shaded area shows defect Tubed flap from neck raised, to supply lining Forehead flap outlined for cover *b*, neck flap turned, skin side in, and sutured over defect. Forehead flap brought down over raw area (Blair)

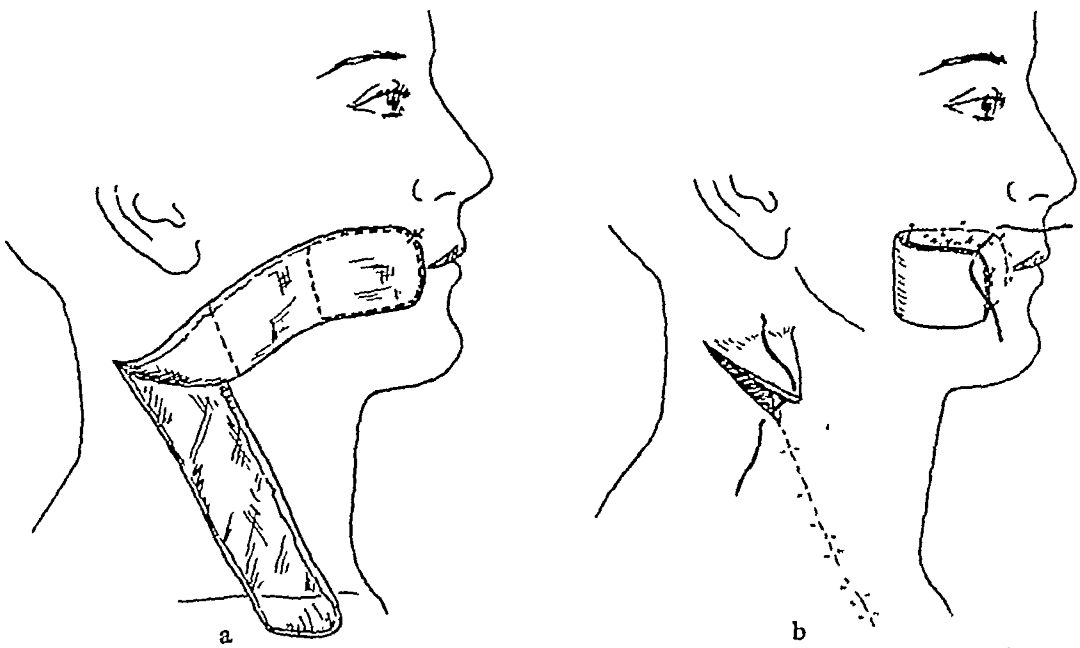

Fig 655 Israel operation for replacement of full thickness loss *a*, neck flap raised and sutured, skin side in, into pared margins of defect Secondary wound in neck closed by direct approximation After vascularization, pedicle cut along dotted line *b*, posterior part of flap folded over raw surface, after granulations have been removed Stump of flap returned to neck At third stage, flap severed at site of reflection Inner layer sutured to mucous membrane and outer layer to skin

supply cover (204) Blair (25) cites a case wherein he corrected a cheek-orbit defect by the use of flaps taken from the neck and forehead, the former furnishing the lining and the latter the cover. Figure 654 is self-explanatory

cut, enough skin being left to be turned over as cover The granulations which have formed on the raw surface are trimmed. The end of the flap is folded over the raw surface and united above and below to the refreshened skin borders of the original defect. At a third stage a perpendicular incision is made through the flap along the site of its reflection. The inner layer is sutured to the mucous membrane and the outer to the skin.

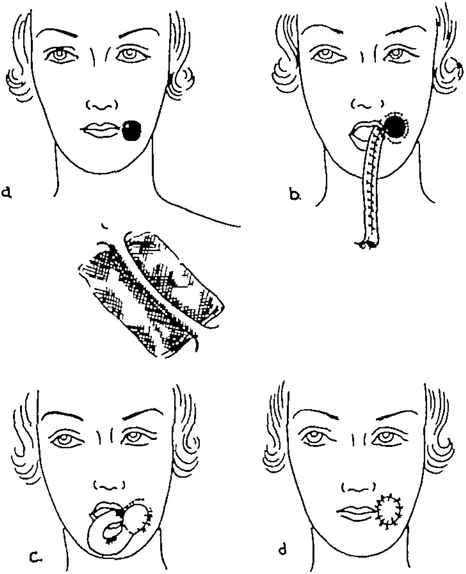

FIG 660 Repair of cheek defect by tubed chest flap *a* flap raised and tubed *b* distal end of tube severed, opened, and sutured into buccal side of defect, to serve as lining. *c* proximal end of tube cut, opened, and attached to skin margins of defect, to supply cover *d* intervening part of tube removed.

Full thickness cheek defects may also be corrected by means of a neck flap pedicled on the upper part of the cheek or along the border of the mandible, the free end being folded on itself to serve as lining (25, 56) (figs. 656–657) After union between the raw surfaces has taken place, the folded flap is rotated and sutured into the freshened margins of the wound Three or 4 weeks later the pedicle is severed and returned to its former position and the balance of the flap is fitted into the defect.

Lauenstein (134) supplies lining and cover by the use of two chest flaps, as follows (fig 658) Two vertical parallel incisions are made on the chest and connected by

pedicle lying just behind the angle of the jaw, is raised from the side of the neck The free end of the flap is sutured into the defect, skin side in The secondary wound is closed by direct approximation At a second stage 3 to 4 weeks later the pedicle is

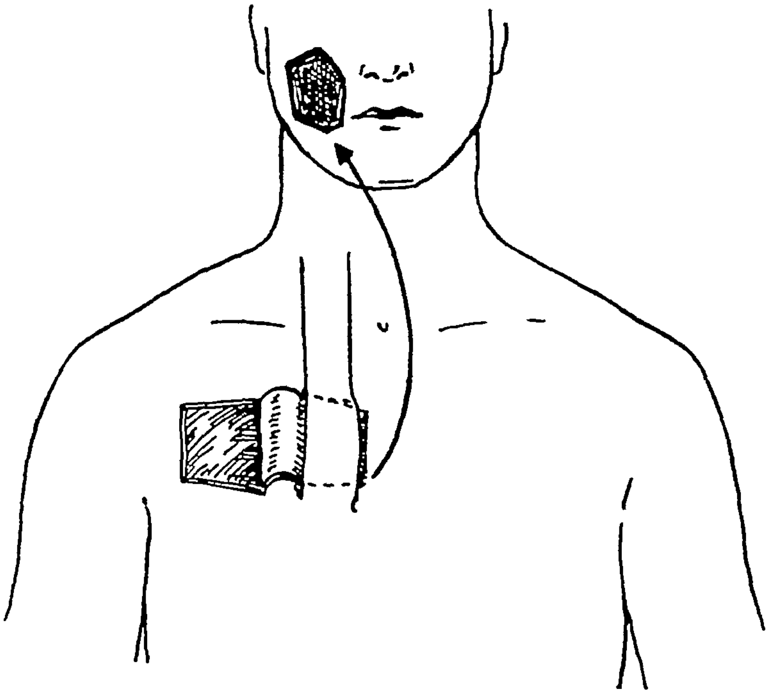

FIG 658 Lauenstein's method for reconstruction full thickness cheek loss Bridge flap raised on chest Contiguous flap turned under, raw surface to raw surface, to supply lining Secondary defect skin-grafted After vascularization, pedicle of turned-in flap severed close to covering flap Lined flap gradually tubed, until free end can be rotated into defect

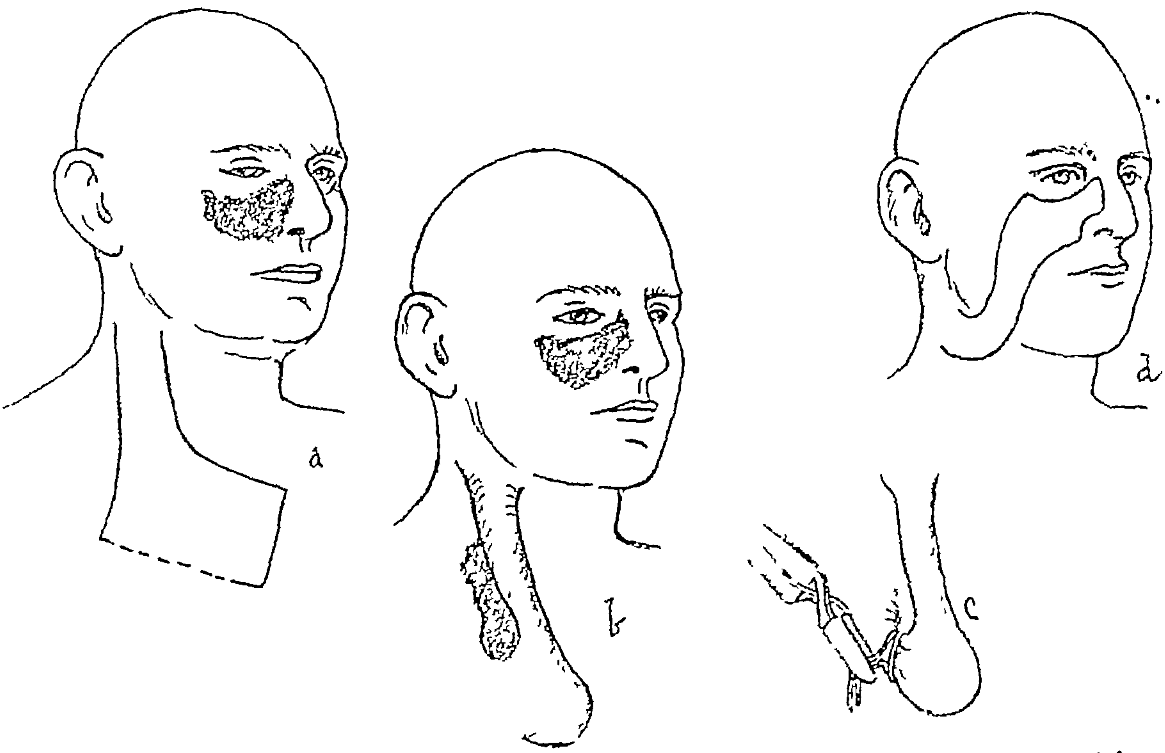

FIG 659 Reconstruction of full thickness cheek loss by chest flap *a*, shaded area indicates defect, solid line, outline of flap, dotted line, part left uncut, to insure better blood supply *b*, flap tubed *c*, pedicle gradually compressed, to enhance circulation *d*, lower end of flap turned on itself, to form lining, and sutured into pared margin of defect (Beck and Guttman)

cut, enough skin being left to be turned over as cover The granulations which have formed on the raw surface are trimmed. The end of the flap is folded over the raw surface and united above and below to the refreshened skin borders of the original defect. At a third stage a perpendicular incision is made through the flap along the site of its reflection The inner layer is sutured to the mucous membrane and the outer to the skin.

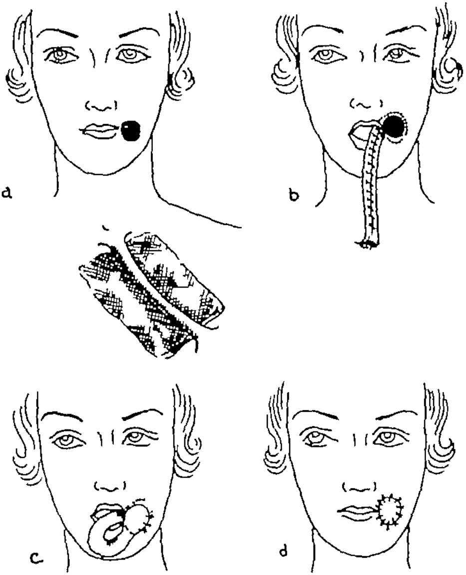

FIG 660 Repair of cheek defect by tubed chest flap a, flap raised and tubed. b distal end of tube severed, opened, and sutured into buccal side of defect, to serve as lining. c, proximal end of tube cut opened, and attached to skin margins of defect, to supply cover d intervening part of tube removed.

Full thickness cheek defects may also be corrected by means of a neck flap pedicled on the upper part of the cheek or along the border of the mandible, the free end being folded on itself to serve as lining (25, 56) (figs. 656–657) After union between the raw surfaces has taken place, the folded flap is rotated and sutured into the freshened margins of the wound Three or 4 weeks later the pedicle is severed and returned to its former position and the balance of the flap is fitted into the defect.

Lauenstein (134) supplies lining and cover by the use of two chest flaps, as follows (fig 658) Two vertical parallel incisions are made on the chest and connected by

undermining to form a bridge flap A quadrilateral flap is then outlined, with its pedical just beyond the margin of one or the other vertical incision This flap is elevated and turned in under the bridge of tissue, and the raw surfaces are permitted

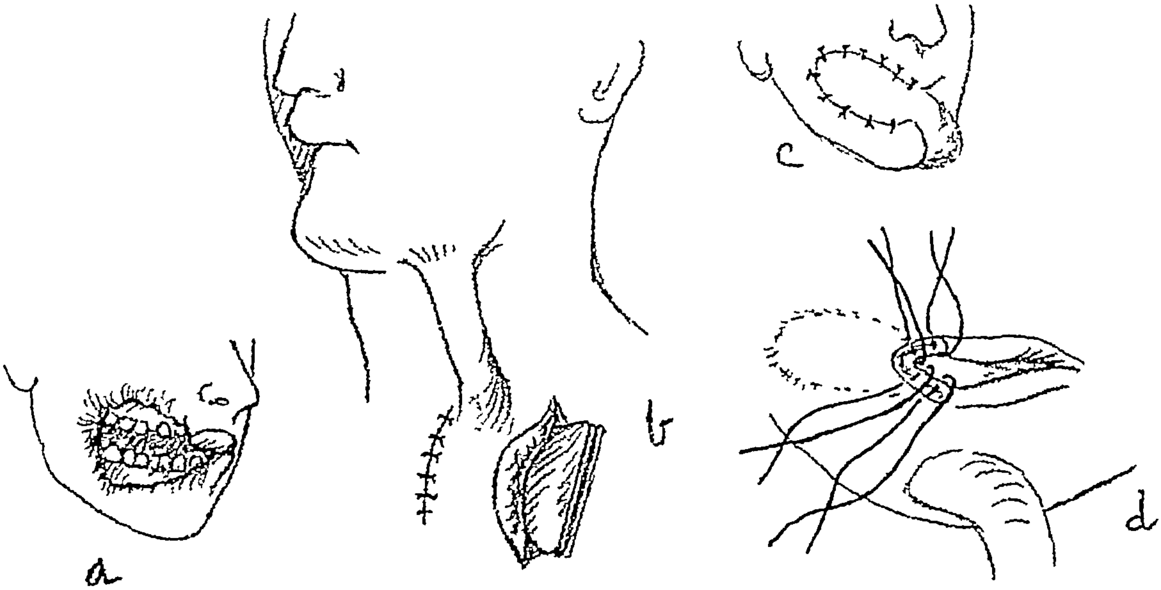

FIG 661 Repair of full thickness cheek and lip defect with lined chest flap *a*, defect. *b*, neck flap raised and tubed. At second stage, lower portion of flap lined with full thickness skin graft on stent mold *c*, at third stage, distal pedicle of flap cut, and lined portion sutured into defect *d*, after vascularization, pedicle cut close to cheek, stump returned to neck, and commissure modeled (Martin-Figi)

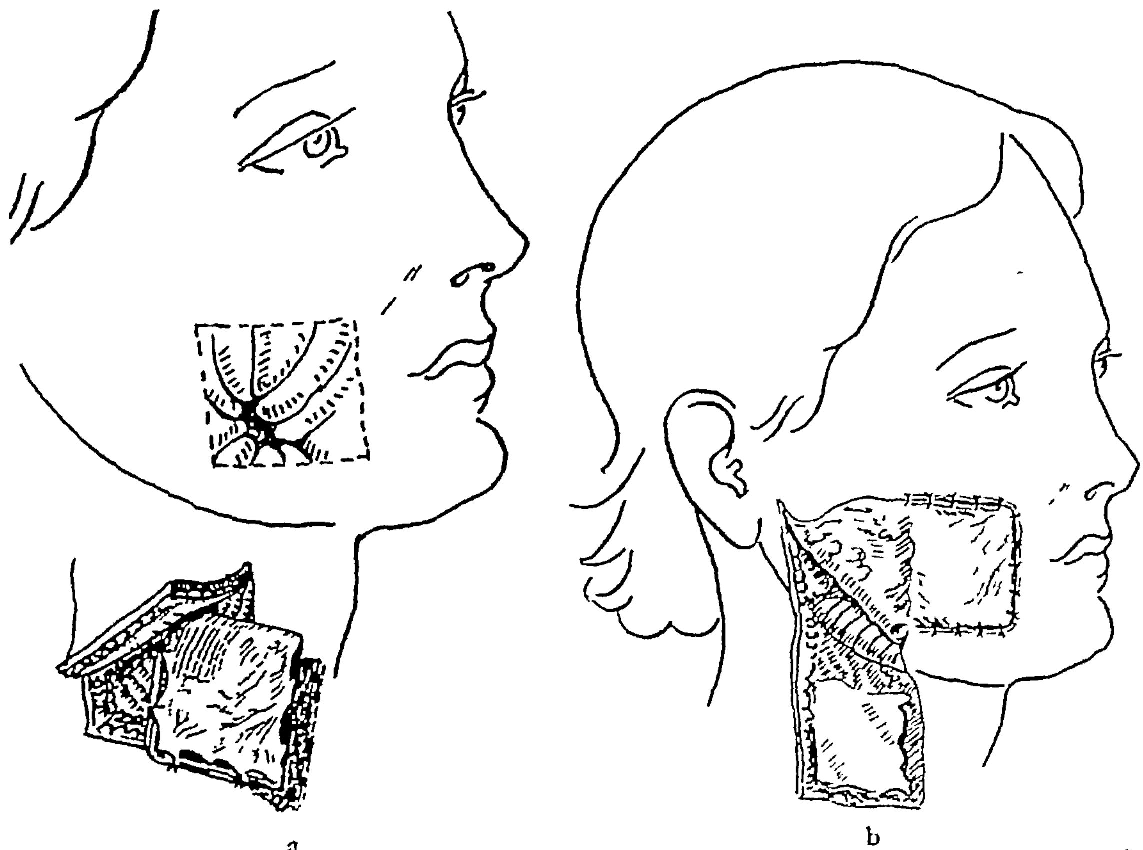

FIG 662 Repair of full thickness cheek defect by skin-lined neck flap *a*, neck flap raised Under surface of flap and donor area skin-grafted on stent mold *b*, pedicle gradually extended, until lined flap can be sutured into defect (Rosenthal)

to unite After the circulation has become established, the pedicle of the turned in flap is severed. The vertical incisions are gradually extended upward, and the flap is tubed. When the pedicle comes to lie along the lower margin of the mandible the free lined end is rotated into the defect and sutured to its freshened margins

The loss may also be repaired by the use of a single chest flap, as described by Beck and Guttman (19) (fig 659), or by a tubed chest flap (figs 660–661)

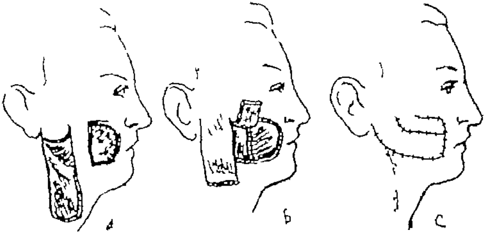

FIG 663 Repair of full thickness cheek defect by combined neck and cheek flaps. *a*, neck flap, pedicled on angle of mandible, raised, passed under bridge of cheek tissue, and sutured, skin side in, to pared margin of defect, to serve as lining. *b* after vascularization pedicles of lining and bridge flaps severed. *c* free ends of flaps rotated over defect, to supply cover (von Hacker)

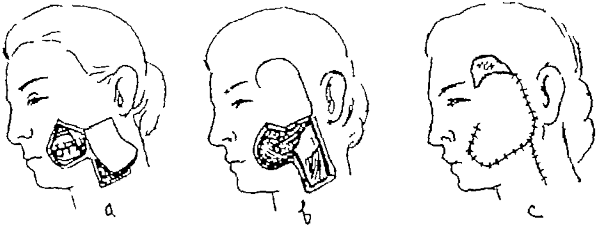

FIG 664. Repair of full thickness cheek loss by neck-cheek flap for lining and advancement cheek flap for cover *a* flap of cheek and neck tissue raised. *b* flap turned, skin side in, and sutured to buccal mucosa. Incision for covering flap outlined. *c*, covering flap mobilized, slid over defect, and sutured in place. (Pólya)

Rosenthal (201) raised a neck flap pedicled below the mandible, inserted an epidermal graft between the raw surfaces, and after the graft had "taken extended the pedicle and rotated the flap skin surface in into the defect (fig 662)

Von Hacker (94) elevated a neck flap pedicled at the angle of the mandible, turned it, skin side in, under a bridge of cheek tissue, and sutured it into the defect, thus supplying the lining After organization had taken place he severed the pedicle of the lining flap and the lower end of the bridge flap The two contiguous flaps thus liberated he rotated into the wound to serve as cover (fig 663)

Pólya (189) secured lining from a flap composed of neck and cheek tissue and cover from a sliding cheek flap, as advocated by von Imre and Esser (fig 664)

Esser (64) employs a rotation flap, as follows: The incision is outlined in the same manner as described for the replacement of cheek skin alone (p 1039), but is deepened to include the mucosa, care being taken that the mucosal incision is terminated before is reaches the parotid duct The flap is undermined posteriorly and rotated into the defect The secondary wound in the neck can usually be closed by direct approximation Esser claims that with ordinary precautions the danger of injuring the facial nerve and parotid duct is not great Should small fistulae remain, they are cleansed with ether, and a small pledget of cotton saturated with a drop or two of collodion is

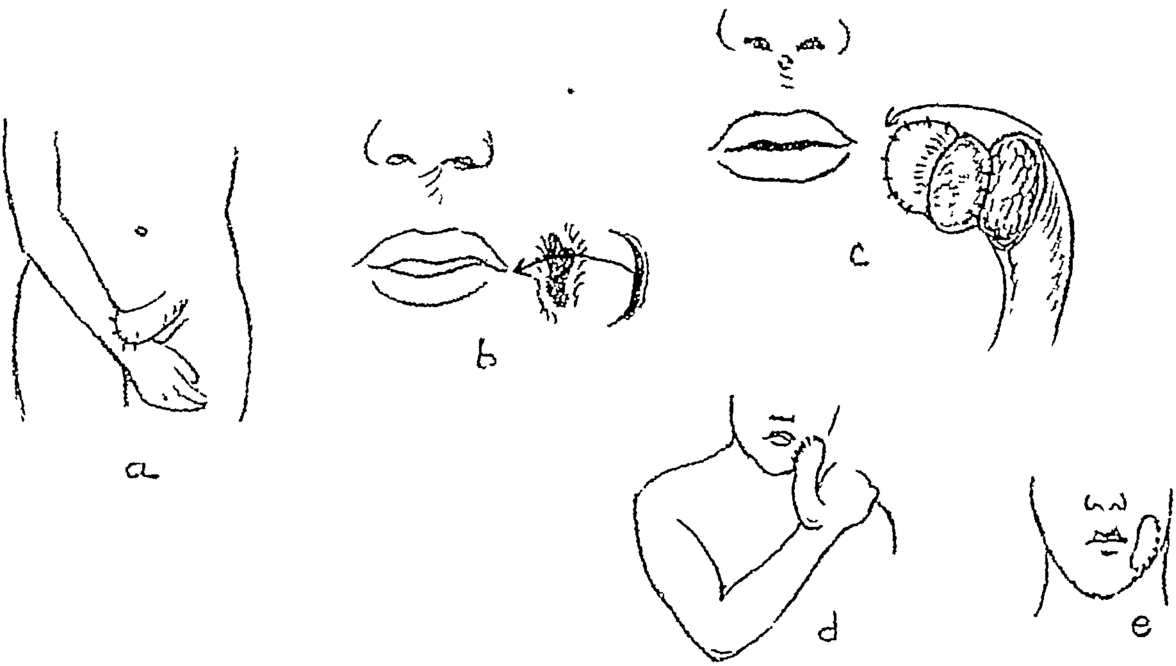

FIG 665 Reconstruction of full thickness cheek loss with tissue from a distance *a*, abdominal flap elevated, tubed, and medial end attached to wrist *b*, flap outlined on skin adjacent to defect, to be turned in for lining *c*, cheek flap turned in and sutured into margin of defect Flap separated from abdomen, and transferred to defect on arm carrier, to supply cover *d*, position of arm *e*, donor pedicle cut Arm released, and remainder of flap fitted into defect (New and Erich)

pressed into them with the finger This dressing is removed in 24 hours and the part re-dressed at intervals until healing is complete

The repair of a cheek defect with tissue taken from a distance is depicted in Figure 665

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CHAPTER XV

THE LIPS

ANATOMIC CONSIDERATIONS

The lips are two musculomembranous folds converging in lateral commissures. They enclose a transverse slit, the buccal orifice. The upper lip is suspended from the columella and extends vertically from the base of the nose above to a free border below, blending laterally with the cheeks. The medial portion of the upper lip projects farther downward than the balance of the lip and shows a vertical depression, the philtrum, which terminates at the free border in a tubercle.

From without inward the lips are composed of skin, superficial fascia, orbicularis oris muscle, submucous areolar tissue containing vessels and labial mucous glands, and mucous membrane, the exposed portions of the latter forming the vermilion borders. The abundance of connective tissue accounts for the extensive swelling following injury, and the absence of a fixed bony attachment is responsible for the marked deformities consequent upon cicatricial contractions. Fortunately, however, the laxity of the tissues and the excellent blood supply facilitate reconstructive operations in this region.

Intra-orally, the mucous membrane of the lips merges with that of the jaws, and the lines of junction are called the gingivolabial sulci. At the center of each of these folds is a web of mucosa prolonged to the gum—the fraenum labiorum.

The muscular layer is composed chiefly of the orbicularis oris muscle, a sphincter into which converge the facial muscles. Closure and pursing of the lips are produced by the activity of the orbicularis, and other lip movements by the contraction of the bilateral facial muscles which are inserted into it. Deaver's (25) description of the orbicularis oris can hardly be improved upon. "The orbicularis oris muscle (sphincter oris), nearly an inch in breadth, surrounds the mouth, forming a sphincter, at its periphery it unites with several muscles which act upon that aperture. It consists of two parts—an inner, central, or labial part, and an outer peripheral, or facial part. . The inner, central, or labial portion consists of pale, thin fibers, fine in texture, corresponds in position with the red margin of the lips, and has no bony attachment, but is continuous around the angles of the mouth from one lip to the other. The outer, peripheral, or facial part is thinner and wider than the labial, and has a bony attachment as well as connection with the adjacent muscles. In the upper lip the orbicularis oris muscle is attached at each side of the middle line to the lower part of the septum nasi by the naso-labial slips, and to the alveolar border of the upper jaw opposite the incisor teeth, in the lower lip it is attached to the alveolar border of the lower jaw opposite the canine teeth by a single fasciculus (Musculi incisivi). The cutaneous surface of the muscle is intimately connected with the skin of the lips and surrounding parts. The intimacy of this union is so great in some instances

that the mouth is surrounded by radiating wrinkles, especially marked in the upper lips of women. The labial integument of the male probably contains fewer wrinkles on account of the presence of large hair bulbs. The deep surface of the orbicularis oris is covered by mucous membrane, between which and the muscle, in the submucous tissue, are the coronary arteries and the labial glands."

The arteries supplying the upper lip are the infra-orbital and superior labial (coronary), and those of the lower lip are the inferior labial, mental, and submental. They are all given off at the angles of the mouth, pierce the muscle, and run immediately beneath the mucous membrane about midway between the border of the lip and its attachment to the gum. As the vessels anastomose freely, their severance necessitates the ligation of the distal as well as the proximal end. The excellent blood supply accounts for the relative resistance to infection in this region and the rapid healing following injuries. On the other hand, as previously stated (p 978), the free vascular communication presents a potential danger The labial veins anastomose with the ophthalmic vessels, which in turn drain into the cavernous sinus. Thus in the case of infection there is the danger of septic sinus thrombosis (fig 614)

The lips receive their motor nerve supply from branches of the facial. Sensation to the upper lip is furnished by the second division of the trigeminal nerve, and to the lower lip by the third division

The labial lymphatics are abundant. The course of drainage from the lower lip was demonstrated in 1900 by Dorendorf (30) who, after injecting a suspension of Prussian blue, showed that the great majority of the vessels entered the submental and submaxillary nodes, a few of them draining directly into the deep cervical group on the same or opposite side and a few entering the mental foramen of the mandible.

WOUNDS OF LIPS

Wounds of the lips are treated in the same manner as wounds elsewhere (p 265) Owing to the excellent blood supply of this region, débridement can be carried out sparingly Special precaution must be exercised to preserve the angles of the mouth, as these structures are difficult to reconstruct. Because of the septic nature of the oral cavity, drainage should be instituted for 24 to 36 hours following closure. The elasticity of the labial tissues permits of the obliteration of comparatively large wounds by direct approximation of the margins. A defect of the lower lip extending over as much as one-third of its length can be approximated directly without great functional disturbance or esthetic impairment. In the upper lip however, there is less latitude, and a loss exceeding 2 cm. requires the addition of new tissue if distortion is to be avoided. The tissues are approximated in layers, and, owing to the elasticity of the parts, tension sutures are unnecessary If the muscle has been severed, its ends must be united, otherwise, its subsequent contraction will cause the cicatrix to spread. One or 2 mattress-sutures of catgut will serve the purpose. The mucosa is next approximated, interrupted sutures of fine silk being used. Finally the skin margins are closed with on-end sutures of fine silk or horsehair, care being taken to preserve a non interrupted mucocutaneous border Forcing of the vermilion border into the skin or vice versa will leave an ugly scar

Dressings are best omitted, as they are likely to become soiled from oral secretions and food. A few layers of gauze, which can be renewed whenever necessary, will

suffice to protect the wound from gross contamination During the process of healing the parts are immobilized by a chin strap attached to a headgear of plaster of Paris or to an ordinary leather hatband (fig 602). Sometimes it is found convenient to fix the lips by sutures, with or without denudation of the margins (1, 2, 67) The patient is fed through a tube or a gooseneck feeding cup, and after each meal the mouth is cleansed with copious quantities of some mild antiseptic The skin sutures are removed in 3 to 4 days, but the intra-oral stitches are left in place for about a week, or until healing is firm enough to permit of eversion of the lip for their removal

In wounds involving a loss of full thickness labial tissue and where it is deemed advisable to delay correction, the skin and mucosa are sutured together to minimize contraction and scarring In the event of extensive bone destruction a prosthesis is worn until the supporting structures can be engrafted, in order to prevent undue distortion of the tissues As a precaution against obliteration of the gingivolabial sulcus, a removable vulcanite flange may be fitted to the splint

RECONSTRUCTIVE OPERATIONS ON LIPS

Reconstructive operations on the lips have occupied the attention of surgeons of all times The Hindus repaired labial defects by rotating flaps from the vicinity (Indian method of cheiloplasty) Celsus described advancement flaps for the purpose. The latter procedure was later revived by French surgeons and is at present referred to as the French method of repair Tagliacozzi (91) (1597) chose to obtain the necessary flaps from the arm and was the first to furnish a detailed description of the technic This principle is still in use and is known as the Italian method Chopart (20) (1785) has left a full account of an operation whereby an advancing flap was taken from the chin and neck for the reconstruction of a lower lip following the removal of a malignant growth He failed, however, to recognize the importance of providing a lining, and the final results proved disappointing The majority of the present operations were devised early in the nineteenth century by such famous surgeons as Delpech (26), Szymanowski (90), Lisfranc (61), Dieffenbach (28), Burow (79), Sédillot (81), Serre (84), Zeis (99), Nélaton (69), von Langenbeck (58), Syme (89), Adelmann (3), and von Bruns (18) Alquié (4) (1854) was the first to realize the importance of a lining and modified Chopart's operation by covering the inner surface of a chin-neck skin flap with a flap of mucous membrane obtained from the cheek Von Bruns (18) in 1859 described 32 different methods of lip repair The greatest progress in cheiloplasty, however, has been made within the past two or three decades Among the great number of surgeons whose efforts and devotion to this type of work have standardized and simplified the technic may be mentioned Blair, Brown, Davis, Gillies, Joseph, Kazanjian, Kilner, Padgett, Pierce, and Webster

Reconstructive operations on the lip are called for in congenital anomalies, such as cleft lip, and in acquired losses resulting from (1) inflammatory and degenerative states—e g , tuberculosis, syphilis, and cancrum oris—(2) the removal of neoplasms, and (3) extensive traumatisms, burns, and irradiation therapy

The most appropriate time for the carrying out of the reconstructive procedure is an important consideration Conditions permitting, it is best done immediately after the loss has been sustained, since a delay leaves a raw surface exposed to infection, and the formation of adhesions due to cicatricial contraction renders repair more

difficult. In addition, the constant drooling of saliva and the interference with mastication and deglutition impairs the health of the patient. Unfortunately, however, most conditions requiring cheiloplasty call for delayed repair If the part is infected, reconstruction must be deferred until the process has cleared up If the bone has been cauterized, it must be postponed until sequestration takes place In the case of losses incident to malignant growths, with the exception of small early lesions of low-grade malignancy, reconstructive measures must be withheld until all likelihood of recurrence has passed—a period ranging from 6 months to a year or more Blair (12), however, favors a shorter interval. He writes as follows "We have selected 3 months as about the period we allow to elapse before we begin with actual repair, though in the more promising cases we often prepare the flaps in the meantime. Three months will give time for exfoliation of bone of the lower jaw which has been devitalized by the cautery and also permits scarring completely or incompletely of the soft tissues after destruction with diathermy, actual cautery or escharotics.'

The aim of cheiloplasty is to provide a mouth of the proper size and shape, with connecting commissures free from distortion, an upper lip with a well-marked vermilion border, and of sufficient width to cover the teeth, and a lower lip of ample height and with an adequate gingivolabial sulcus to prevent drooling of saliva.

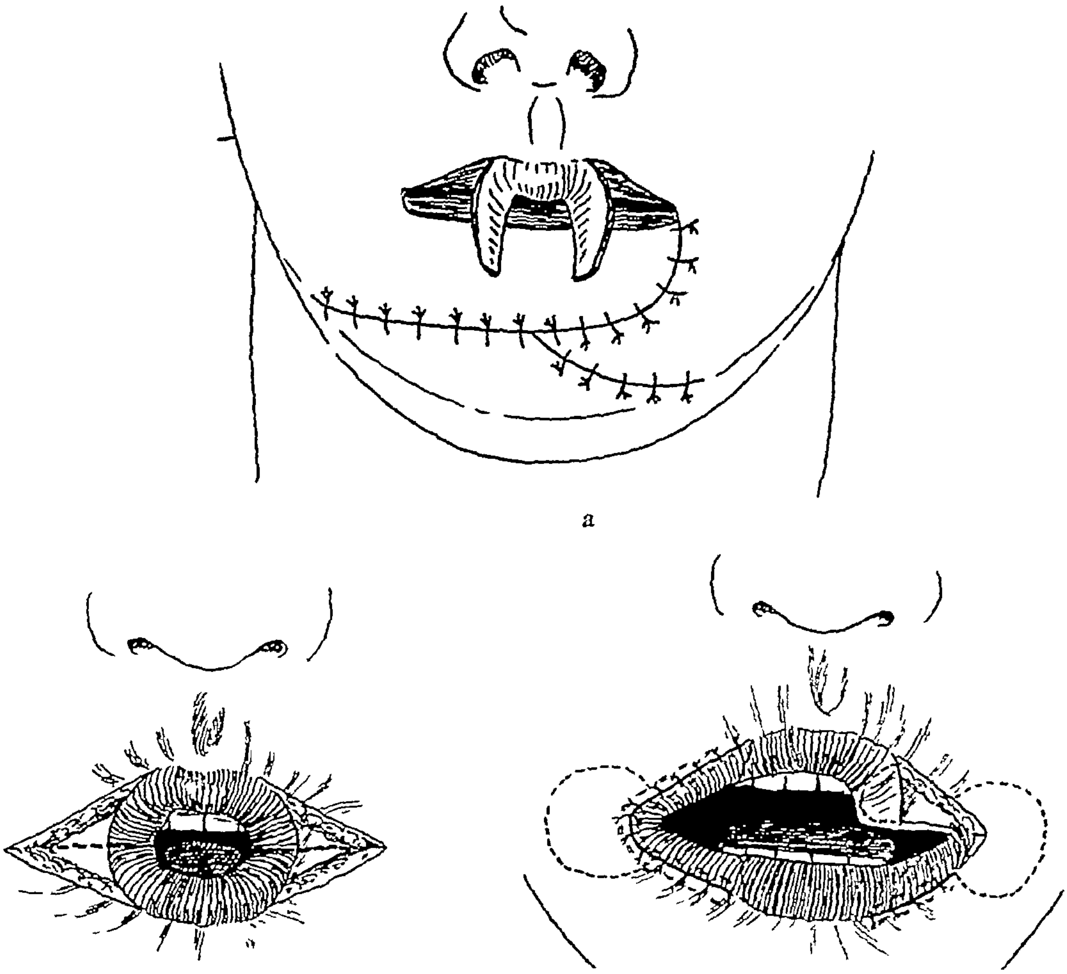
The extent and nature of labial defects vary so greatly that a single operative plan applicable to all cases cannot be outlined. Each patient presents an individual problem which can be solved only by a judicious combination of the advantageous features of several of the operations to be described hereafter Following the initial reconstruction, one or more secondary operations will usually be necessary for the correction of minor deformities, such as residual asymmetry of the commissures unevenness of the vermilion border, tightness of the lip stenosis of the mouth and adhesions between the lips and jaws.

The general *preliminary preparation* is the same as that prescribed for any surgical procedure (p 444) Locally the hygienic condition of the mouth should be improved. The teeth are scaled, and all sources of focal infection, such as carious dental roots, are removed. Gross trauma to the gums by extensive extraction, however, is to be avoided For several days prior to operation the mouth is sprayed at frequent intervals with an antiseptic solution, and at the time of operation it is cleansed with normal salt solution, dried, and swabbed with 2.5 per cent tincture of iodin. Preparation of the skin and draping is carried out in the customary manner

The majority of operations on the lip can be performed under block anesthesia of the second and third divisions of the trigeminal nerve, combined with local infiltration of a 1 per cent procain solution containing 5 to 10 drops of adrenalin (1 1000) to the ounce If a general anesthetic is to be employed the endotracheal method of administration is the one of choice.

Lip repair following a loss of tissue requires careful planning in terms of loss and replacement of each individual layer whether it be skin cover supporting tissue mucous membrane lining or a combination of the three The methods employed for the reconstruction of the several layers of the cheek, as detailed in Chapter XIV, are for the most part applicable to the lip The only structures which call for special mention are the *vermilion border* which if lost demands replacement if the flexibility of the lip is to be preserved and the *gingivolabial sulcus* the absence of which interferes

The margin of the flap is sutured to the pared skin of the lower lip defect along the line of the proposed mucocutaneous junction After a lapse of 10 days the pedicle is cut close to its junction with the upper lip, and the free border of the flap is sutured into the pared margins of the remaining mucous membrane of the lower lip (60). Gillies (43) operates thus (fig 670): The upper lip is everted and the mouth packed off to prevent aspiration of blood An incision is then made along the gingivolabial junction of the central portion of the upper lip. Two *perpendicular* cuts are carried



a

b c

FIG 669 Von Langenbeck-Lexer operation for replacement of vermilion border of lower lip *a*, two flaps raised from upper lip, with common pedicle below philtrum. Flaps sutured around commissures and united to each other at center of newly formed lower lip *b*–*c*, correction of resultant microstomia Triangular sections of skin and subcutaneous tissue excised at commissures Mucosa incised horizontally, rolled out, and united to skin margins, to form new vermilion border Dotted lines show extent of undermining

from the extremities of this incision to the free margin The mucous flap thus outlined is *turned down hinge-fashion.* The sutures are placed but not tied and consist of "one relaxation suture of silk-worm gut from the upper lip to the chin, next a row of four horsehair sutures . . inserted through the mucous flap, and four mattress horsehair sutures through the mucous flap joining it to the mucous membrane of the lower lip. These were inserted about ½ in from the free border of the mucous flap, so that sufficient mucous membrane remained to join the skin" With the sutures in position, the packing in the mouth is removed, the relaxation and the back row sutures are tied, and the free edge of the mucous flap is joined to the skin of the lower lip After 10

days the pedicle is cut under local anesthesia. Defects of the upper lip may be repaired in like manner, as illustrated in Figure 671 (60)

Repair of Gingivolabial Sulcus Following Partial or Complete Obliteration

A diminution in the depth of the gingivolabial sulcus may be due to alveolar absorption following extraction of the teeth, to hypertrophy of the mucous and sub-

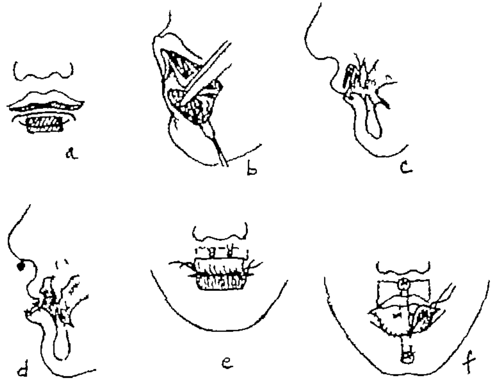


Fig 670. Repair of vermilion border defect in lower lip by flap of mucosa taken from upper ▼a, Incision made along proposed mucocutaneous junction of lower lip Shaded area, outline of fat flap, to give contour to lip b fat flap raised. c sectional view showing outline of mucosal flap raised from upper lip. d–e, flap turned down and sutured into prepared bed in lower lip. f showing relaxation suture extending from upper lip to chin. For details see text (Gillies)

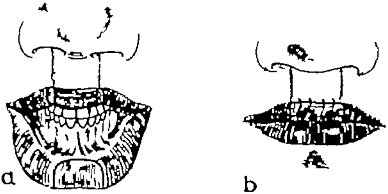


Fig. 671 Repair of vermilion border defect in upper lip by flap taken from lower a, flap outlined on lower lip b flap elevated and sutured into defect. After vascularization donor pedicle cut, and flap fitted into remaining margin of defect. (Lexer)

mucous tissue, or to trauma. Complete obliteration of the sulcus usually results from extensive necrosis, ulceration, or burns.

A partial destruction can be corrected by liberating the lip and covering the raw surface with a contiguous flap of mucous membrane. Kazanjian (52) operates in

the following manner (fig 672) "A horizontal incision is made on the surface of the lip or cheek on a line parallel to the alveolar ridge and about 1 5 cm externally from it With a sharp instrument, the loose tissues under the mucous membrane are undermined and freed from the membrane as far down the external side of the periosteum as is necessary This loose flap of tissue attached to the alveolar ridge is then pushed or folded down against the periosteum and sutured in place The raw surface on the lip or cheek is then closed by suturing together the top and bottom margins of the raw area Sutures may be passed through the skin, if necessary, since these do not leave any permanent scars "

If the gingivolabial sulcus is completely obliterated, the above procedure will be inadequate In such cases the most uniformly satisfactory results are obtained by freeing the lip, excising all cicatricial bands, and covering the remaining raw area with a skin graft wrapped about a stent mold after the manner of Esser (33, 34), thus (fig 74) Through an incision just below the chin a pocket is created between the

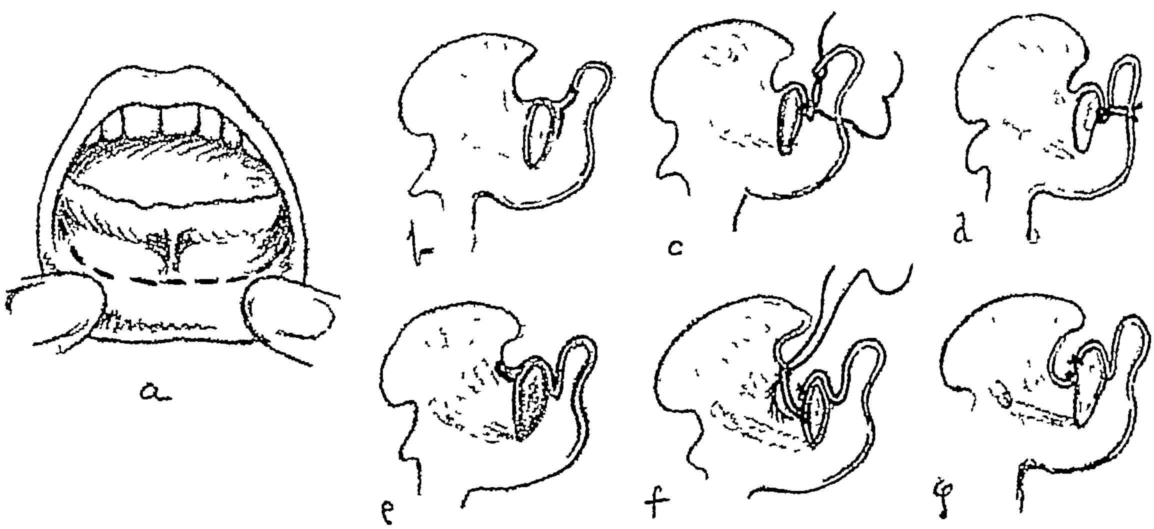


FIG 672 Correction of partial obliteration of gingivolabial sulcus *a*, horizontal incision made parallel to and 1 5 cm from alveolar ridge *b*, sectional view of incision *c*, tissues undermined Flap pushed down against periosteum and sutured in place Remaining raw area of inner surface of lip closed by direct approximation *d*, suturing completed *e-f-g*, similar procedure used to deepen ridge along lingual side of mandible (Kazanjian)

soft tissues and the mandible up to the obliterated sulcus, care being taken to avoid penetration of the oral cavity. After hemorrhage has been controlled, an impression of the cavity is made in stent, and around the mold a razor graft, taken from a hairless portion of the body, is wrapped, raw surface out The graft-covered mold is reinserted into the pocket, and the wound closed over it At the end of 10 days the pocket is opened intra-orally and the mold removed leaving a skin-lined cavity opening into the mouth The mold is cleansed and replaced through the oral incision and worn until all danger of contraction has passed—a period ranging between 2 and 3 months—being removed daily for cleansing purposes

The external scar may be avoided by the introduction of the skin-covered mold intra-orally Despite the septic nature of the cavity, these grafts "take" well Prior to operation a prosthesis with a removable tray is constructed, and cap-splints are affixed to the teeth for its attachment, in order that the mold may be retained in the desired position and firm even pressure exerted during the healing in of the graft.

The obliterated sulcus is incised intra-orally, all scar tissue is resected, and the lip is separated from the bone. Since the graft is bound to undergo considerable contraction—as much as 50 per cent—it is essential that the cavity be made large enough to compensate for such shrinkage. After hemorrhage has been controlled, a piece of softened stent is placed on the tray of the splint and pressed into the cavity. When hardened, the mold is removed and covered with a razor graft. The cavity is then cleansed, the graft-covered mold introduced, and the upright of the tray fixed to the cap-splints on the teeth (fig. 673). Additional support is furnished by means of an adhesive strap applied across the lip. The mouth is kept clean by frequent irrigations. At the end of a week or 10 days the mold is withdrawn, cleansed, and replaced. It is worn for 2 or 3 months thereafter, being removed daily for cleansing. When all tendency to shrinkage has ceased, a properly fitting dental plate equipped with an extension to occupy the buccal sulcus is constructed. In the case of edentulous patients the mold may be held in place by a Kingsley splint (p. 1213), or it may be buried beneath the tissues and the borders of the wound sutured over it.

Occasionally the lip is bound down by an abnormally short frenum or by cicatricial bands which not only cause an interference with the function of the lip but render impossible the proper fitting of a denture. Correction can frequently be accomplished by excising the band horizontally, undermining the tissues, and uniting the margins in a vertical direction (fig. 674) (74), or by lengthening the band by means of a Z-plastic operation (fig. 675) (52).

The frenum may be abnormally broad and be attached to the central papilla of the premaxilla, separating the central incisors. In such cases correction should be delayed until the eruption of the permanent teeth. The frenum is outlined by a V-shaped incision carried down to the periosteum, the apex of the V extending between the incisor teeth. The lip is forcibly drawn upward and the margins of the remaining wound are undermined for a distance sufficient to permit of approximation (fig. 676) (45). Orthodontic measures are then instituted for the correction of the diastema.

Repair of Full Thickness Lip Losses

Repair of total thickness defects of the upper or lower lip may be accomplished by means of (1) *flaps taken from the vicinity*—(a) by direct advancement, (b) by swinging advancement, (c) by transposition, (d) by rotation, and (2) *flaps taken from a distance*.

Repair by *direct advancement* of the margins of the defect (4, 20, 61, 84) violates a fundamental principle by the tension it induces and by its failure to restore the lost tissue. It is therefore applicable only to the closure of small defects. In the case of more extensive losses repair by this method would result in an unnatural distortion of the tissues, the reconstructed lip appearing short and tense with the unaffected lip protruding noticeably beyond it, the corners of the mouth deranged, and a limitation of muscular control.

Swinging advancement flaps taken from the vicinity of the defect have the advantage of carrying a lining membrane and muscle tissue. These flaps, however, leave much to be desired. They are rigid, produce distortion and buckling, and predispose to the formation of fistulae. The possibility of the flap carrying functioning muscle is more theoretical than practical since in the process of its elevation the nerve supplying the

muscle is necessarily severed When ascending flaps are taken from the lower face and neck, the unavoidable severance of branches of the facial artery endangers their nutrition, considerable torsion is required to rotate them into place; and the subsequent

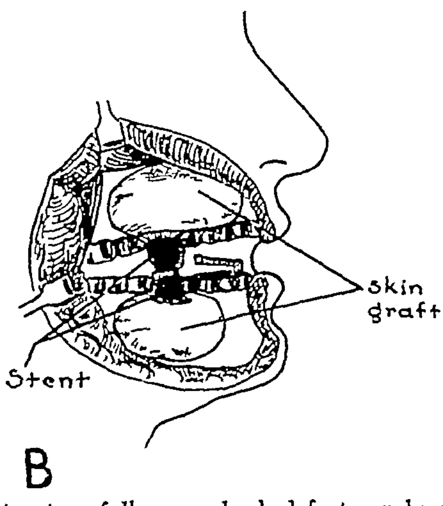


FIG 673 Repair of scar contraction following cheek defect involving skin and buccal mucosa A, defect B, buccal sulcus lined by skin graft on stent mold, introduced intra-orally and held in place by open-bite splint affixed to teeth (The advantage of the open-bite splint is that it keeps the mouth in an overcorrected position and thus minimizes subsequent contraction) C, external cheek defect skin-grafted (Case of Dorrance, Medical Dept , U S Army, Vol XI)

contraction tends to distort the angles of the mouth, expose the teeth, and leave ugly scars They are capable, however, of providing ample mucous membrane and thus avoid the tendency toward narrowing of the oral aperture, and for men they have the advantage of being hair-bearing Lip reconstructions by means of such flaps

have been described by Sédillot (1846), Szymanowski (1858), Joseph, Dieffenbach, von Langenbeck, Jaesche, Trendelenburg, Burow Blasius Lexer Morgan, and others

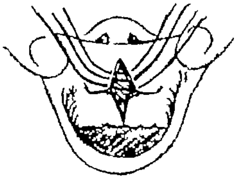


FIG. 674 Correction of abnormally short frenum by readjustment of tissues. Cicatricial band excised horizontally and wound margins united in vertical direction. (Kazanjian)

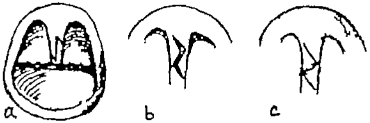


FIG. 675 Correction of abnormally short frenum by Z-plastic. *a* incision outlined. *b* frenum lengthened by transposition of flaps. *c* margins approximated. (Kazanjian)

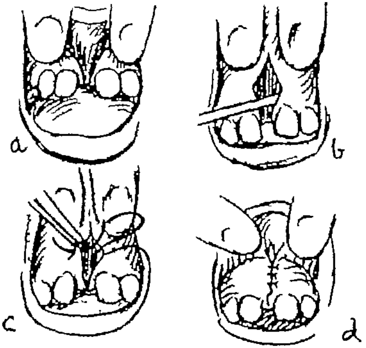


FIG 676 Repair of defect resulting from abnormally low attachment of frenum. *a* V-shaped incision made along gingival attachment of frenum. *b* lip drawn up and mucoperiosteum raised from bone. *c–d* diamond-shaped wound sutured vertically (Henry)

When descending flaps are taken from the cheek, the material available for reconstruction is scanty, and the limited quantity of mucous membrane lining predisposes to puckering at the corners of the mouth, they incur the danger of injury to the parotid duct, parotid gland, and facial nerve, and finally, in men there is the added disadvantage that the flap does not carry hair They are however, superior in many respects to

those procured from the lower part of the face and neck, inasmuch as they are anatomically in correct relationship with the facial arteries; there is less tendency on the part of the new lip to contract and expose the teeth, the angle of the mouth is not so likely to become depressed, and the residuary scars are inconspicuous Examples of the use of this type of flap are the operations of Szymanowski, Denonvilliers, Nélaton, Ombrédanne, Zeis, von Bruns, Estlander, and Israel

Rotation flaps provide the most satisfactory means of repairing large lip defects. In the case of men such flaps are best procured from the scalp, since in time the growth of the hair will hide the scar, and for women from the forehead Such flaps furnish a good color match and provide an excellent blood supply, especially if pedicled on the temporal artery, and the residuary cicatrix can be concealed by the coiffure.

Flaps taken from a distance have the great advantage of furnishing sufficient material for the replacement of a loss of any size and entail no secondary scarring of the face, but unfortunately they do not match the skin surrounding the defect, furnish no functioning muscle, require more prolonged hospitalization, and necessitate irksome immobilization

Lining can be provided either by doubling the flaps on themselves or by skin-grafting their under surface The latter method is preferable, inasmuch as folded-over flaps (23, 59) are usually too thick, even when the subcutaneous fat has been removed.

Reconstruction of Lower Lip

As in the replacement of all tissue losses, the choice of method for repair will be governed by the size, shape, and location of the defect

Repair by Advancement Flaps

If the loss of tissue at the free margin of the lip does not exceed 2 or 3 cm in width' the defect may be closed directly As an aid to approximation, the wound is given the shape of the letter V, the base lying along the vermilion border (35), and as a precaution against shortening of the vertical length of the lip from cicatricial contraction, the margins are pared in such a manner that they will be slightly concave. The wound is sutured in layers, catgut being employed for the closure of the mucous membrane and muscle, and fine silk or horsehair for the skin (fig 677) For the obliteration of small quadrilateral defects of the lower lip, von Langenbeck (58) and Maas (62) mobilized the margins by means of 2 incisions extending from the lower border of the defect around the commissures into the upper lip, and approximated the flaps thus formed (fig 678).

For extensive losses closure by direct approximation is inapplicable, since it would produce an undue narrowing of the mouth, shorten the lip, and derange the commissures In such cases reconstruction may be accomplished by recourse to swinging advancement flaps from the cheek or neck

Large triangular defects can be closed by a modification of Dieffenbach's (3, 9, 90) procedure (fig 679): An arched incision is [illegible] de through the skin and subcutaneous tissue, extending from the upper part [illegible] t across the cheek to a point within 6 cm of the tr[illegible] front part [illegible] on is deepened through the muscle, care being ta[illegible] perforation [illegible] membrane, and its upper margin

is undermined in the plane between the muscle and the mucosa for a distance of 2 cm., at which level the mucosa is cut parallel with the original incision The quadrilateral flap of mucous membrane thus formed is used later for the reconstruction of the vermilion border The posterior part of the incision is deepened to the masseteric and parotid fascia only The parotid duct is separated by blunt dissection and displaced upward to protect it against injury From the posterior extremity of the primary incision the knife is carried obliquely downward to a point beneath the mandible, penetrating skin and subcutaneous tissue only A similar procedure is carried out on the opposite side. After the flaps have been separated from the mandible, they are advanced toward the midline and approximated. The surplus flap of mucous membrane previously separated is rolled over the raw margin of the flap and sutured

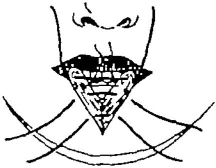


FIG 677 Repair of full thickness defect of lower lip by direct advancement of contiguous tissues Defect trimmed in shape of V to facilitate approximation. Margins sutured in layers. (Estlander)

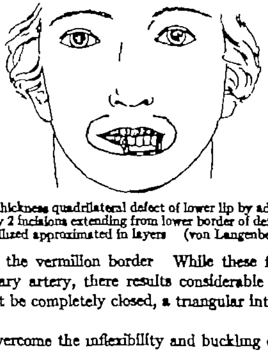


FIG 678. Repair of full thickness quadrilateral defect of lower lip by advancement flaps from upper Margins of loss mobilized by 2 incisions extending from lower border of defect around commissures into upper lip Flaps thus mobilized approximated in layers (von Langenbeck)

to the skin to replace the vermilion border While these flaps are well nourished by the external maxillary artery, there results considerable scarring, and since the secondary defect cannot be completely closed, a triangular interval is left at the outer margin of the flap

In an endeavor to overcome the inflexibility and buckling of the flaps in the Dieffenbach operation, Krauss (56) (fig 680) employed the following procedure A small mucous membrane flap is raised on the vermilion border of the upper lip, to be used later for the reconstruction of the commissure From this flap a horizontal incision penetrating skin and subcutaneous tissue is carried across the cheek to a point within 6 cm. of the tragus, whereupon it is arched upward toward the inner canthus. The flap thus outlined, composed only of skin and subcutaneous tissue, is elevated and retracted. The horizontal limb of the incision is then deepened through the muscle

mucosa the mucosal sides of the triangle on the same side are sutured (8) Closure of the wound on the opposite side is then carried out in the same manner (9) Suture of the flaps in the anterior gingivolabial sulcus is next in order, continuing up the midline and over the free border of the lip along the skin edge and then down to the point of the chin (fig 681-e) (10) The vertical wounds above the commissure are then closed and the mucosal flaps from the triangle trimmed and sutured over the raw surfaces of the new lower lip (11) The last stage of the operation is the adjustment of the submental skin flap which is trimmed and sutured in place in the form of a Y.

Postoperatively the patient is fed through a nasal tube for the first 48 hours The mouth is irrigated at frequent intervals with hot saline solution The more superficial

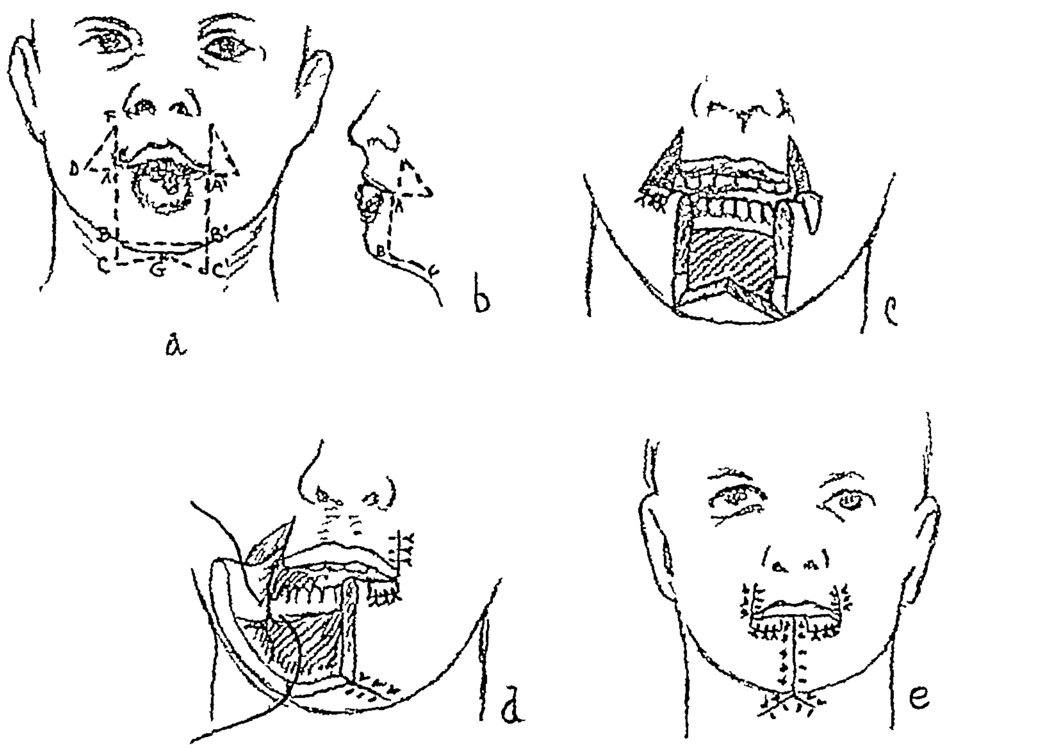
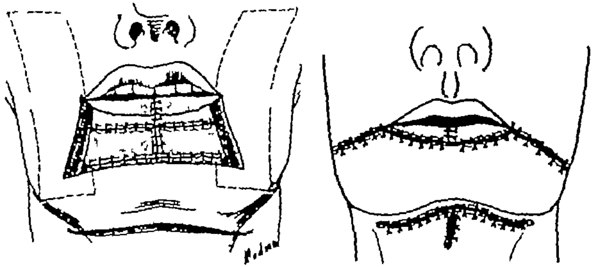


FIG 681 Closure of quadrilateral defect of lower lip by 2 lateral cheek flaps mobilized from mandible Lip lengthened in horizontal direction by removal of 2 triangles of skin and subcutaneous tissue from above and lateral to commissures Conserved mucosa reflected forward and sutured to skin, to form vermilion border of new lip *a*, *A–B–B′–A′*, incisions for removal of pathologic tissue Area outlined by *B–B′–C′–C* left attached until end of operation, at which time it is trimmed to fit triangular defect in submental region *D-E-F*, triangles of skin to be excised *b*, lateral view of incision *c*, skin triangles removed, and mucosa turned over, to replace vermilion border *d*, suturing of left side completed First suture passed for closure of mucous membrane on right side *e*, operation terminated For details, see text (Martin)

sutures are removed on the second day and all sutures on the fourth day, with the exception of the intra-oral ones which remain until the sixth or seventh day

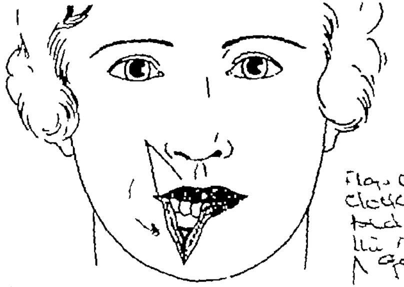
A neck-chin flap (46, 66, 68, 95, 96) lined by oral mucous membrane may also be employed for the purpose (fig 682) From either side of the defect a flap with its pedicle at the level of the commissure and consisting of mucous membrane and some muscle fibers is outlined by an incision, separated from the underlying tissues, rotated upward and inward, and united below to the mandibular mucosa and in the midline to its fellow If this flap does not furnish sufficient material, additional mucosal flaps may be turned down from the cheek, as illustrated in the *diagram* Covering is furnished by a thick under-chin flap in the form of a visor, pedicled at the angles of

the mandible. The upper margin of the flap is sutured to the lower margin of the defect The secondary wound in the neck is closed by direct approximation



a b

FIG. 682. Reconstruction of lower lip by neck-chin flap *a*, lining replaced by mucosal flaps (indicated by dotted line) turned down and up respectively and approximated. Covering flap outlined by incision in neck *b* double-pedicled neck-chin flap mobilized, shifted upward over defect, and sutured in place. Mucous membrane turned over and united to skin of newly constructed lip. (Morgan-Holmann)



Flap can be rotat[ed]
clockwise only
pedicle is ...

FIG 683 Repair of moderately-sized defect in lateral region of lower lip by flap taken from upper Defect pared in form of triangle Flap of corresponding size and shape outlined by incision through full thickness of upper lip. Flap rotated clockwise and sutured into defect. Secondary wound closed. After vascularization pedicle cut. Remaining wound margins approximated. (Estlander)

Repair by Rotation Flaps

For the repair of moderately sized defects in the lateral region of the lower lip one of the most satisfactory operations is that of Estlander (35) (1877) The technic is as follows (fig 683) The margins of the defect are pared in the form of a triangle with its base at the vermilion border The size of the defect is carefully measured, and a flap of similar shape but somewhat smaller is outlined on the upper lip, the pedicle lying on the vermilion border and the free end pointing upward The pedicle

of such a flap may be cut to within 5 mm of the border of the upper lip without danger of sloughing, as the coronary artery lies about 3 mm from the free labial margin The incision outlining the flap is deepened through the full thickness of the lip, and the flap is rotated clockwise through an arc of 180°, fitted into the defect of the lower lip, and sutured in place The muscle and mucosa are approximated as one layer with catgut, and the skin with interrupted sutures of horsehair The secondary defect in the upper lip is closed by direct approximation of its margins. As a precaution against tension on the pedicle during vascularization of the flaps, the lips are held together by means of a chin-strap attached to a head cap; or the upper and lower lips may be united by mattress-sutures of silkworm-gut, with or without paring of the apposing surfaces

Throughout the process of healing, the patient is fed by way of a nasal tube In 2 or 3 weeks the blood supply of the flap is tested by compression of the pedicle with

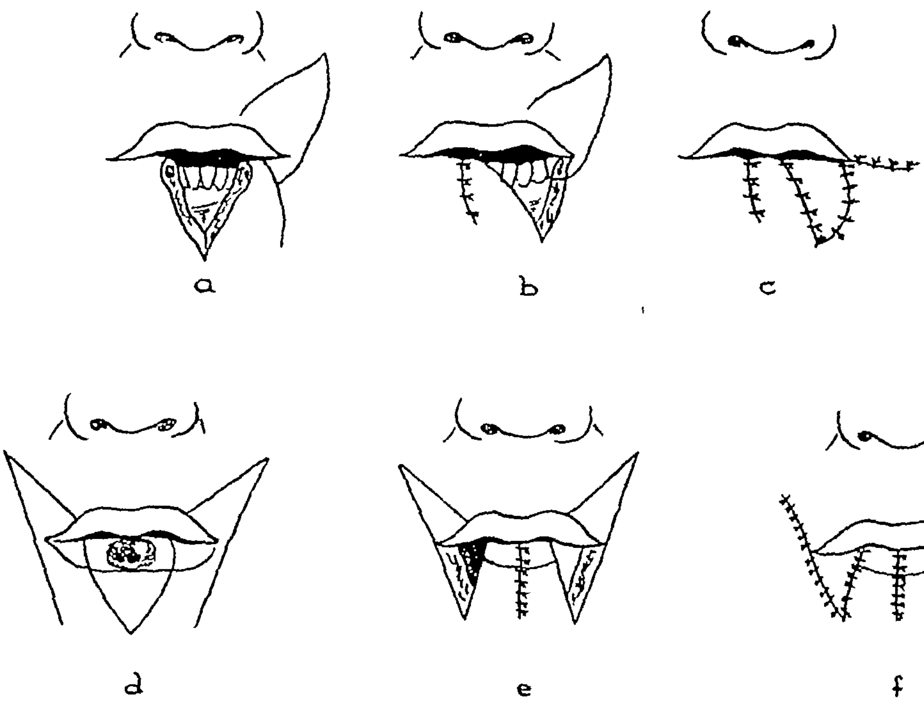


FIG 684 Repair of central defect of lower lip *a*, flap outlined on lower lip, to be shifted inward to obliterate central defect Flap outlined on upper lip, to fill secondary defect *b*, lower lip flap shifted into midline and sutured in place *c*, upper lip flap rotated through arc of 180 degrees and sutured into secondary defect *d-f*, plan for repair of extensive defects by 2 flaps from upper lip (Padgett)

a soft clamp for an hour over a period of several days When the flap is deemed viable, the pedicle is cut Should there be a question as to its vascularity, the coronary artery is divided and severance of the pedicle delayed until a satisfactory circulation has been established (17). Secondary minor modeling operations will be necessary to secure the desired results

For the repair of central defects the use of the Estlander flap would obviously incur too much torsion In such instances the central portion may be built out by means of a rectangular flap shifted into it from the outer part of the lower lip The secondary wound thus created at the outer corner is then closed with a flap obtained from the upper lip, in the manner described above (72). In the case of extensive losses two such flaps may be used, one taken from either side of the upper lip. Figure 684 is self-explanatory

A complete loss of the lower lip can be repaired with two nasolabial flaps pedicled on the sides of the defect and comprising the entire thickness of the cheek, the mucous membrane being separated 1 cm. higher up to allow for reconstruction of the vermilion border (18, 34, 82 90) (fig 685) During the cutting of the mucous membrane care should be taken to avoid injury to the parotid duct. The flaps are rotated downward to meet in the midline and are united in layers. The excess mucous membrane is then folded over the margin and joined to the skin to form the vermilion border Secondary modeling operations around the commissures are usually necessary following this operation.

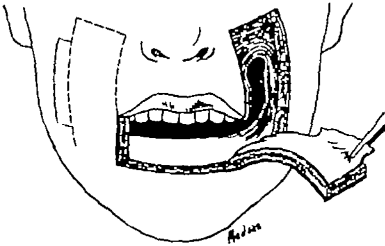


FIG. 685 Reconstruction of lower lip by descending cheek flaps. Full thickness cheek flaps, with excess mucous membrane, to replace vermilion border turned down and united in midline. Excess mucous membrane turned over and united to skin, to form vermilion border Secondary wounds in cheek approximated. (von Bruns-Szymanowski)

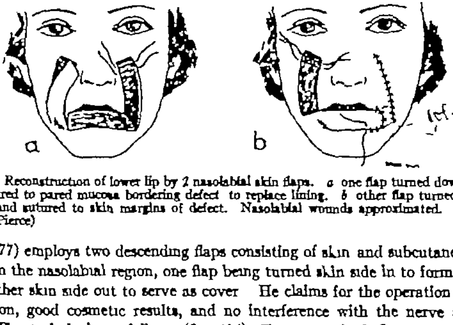


FIG 686. Reconstruction of lower lip by 2 nasolabial skin flaps. *a* one flap turned down, skin side in, and sutured to pared mucosa bordering defect to replace lining. *b* other flap turned down over lining flap and sutured to skin margins of defect. Nasolabial wounds approximated. For details, see text. (Pierce)

Pierce (77) employs two descending flaps consisting of skin and subcutaneous tissue taken from the nasolabial region, one flap being turned skin side in to form the lining and the other skin side out to serve as cover He claims for the operation simplicity of execution, good cosmetic results, and no interference with the nerve and blood supply The technic is as follows (fig 686) Two nasolabial flaps are raised consisting of skin and subcutaneous tissue only and with their pedicles below at the margins of the defect. The flap from one side is brought down, turned skin side in to form the lining of the lip and sutured to the pared mucosa bordering the defect The flap from the other nasolabial fold which is to furnish the cover is then lowered and placed

over the lining flap, raw surface to raw surface, and its margins are sutured to the skin margins of the defect Pierce asserts that the apposing flaps form a bridge between the two ends of the severed orbicularis and restore its function as a sphincter muscle. For the formation of the angles of the mouth small flaps of mucous membrane are taken from the lateral borders of the defect and fitted into the superior border of the sutured flap The vermilion border is created from the mucous membrane of the other lip

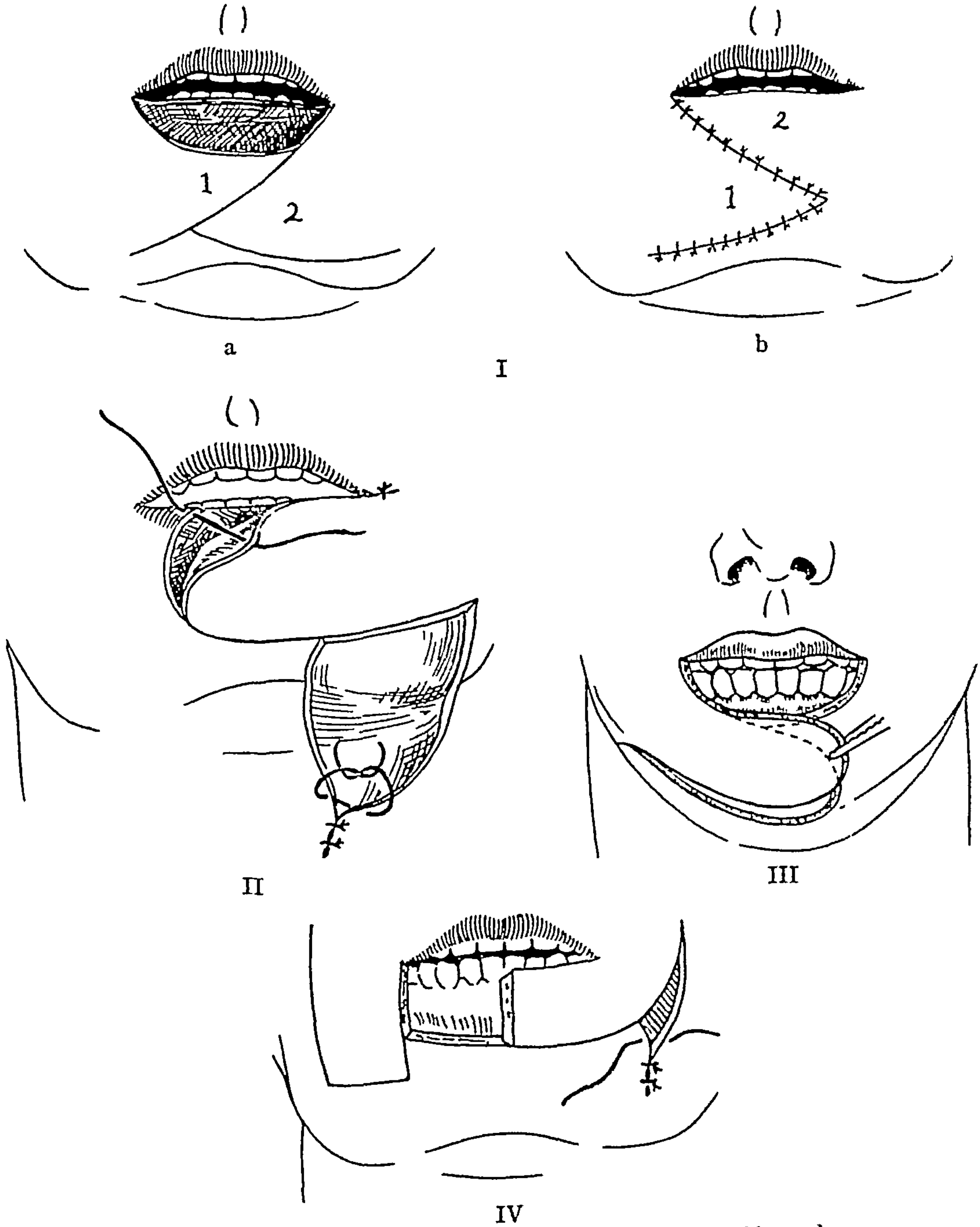


FIG 687 Various types of buttress flaps for restoration of lower lip

The pedicle is cut in 2 weeks, and 2 or 3 months later final "retouching" operations are carried out

Repair by Transposed Flaps

Small defects can frequently be closed advantageously by the use of buttress flaps from the chin and neck (57, 58, 60, 82) Figures 687 and 688 are self-explanatory.

Repair by Flaps from a Distance

When flaps from a distance are used (fig 689), lining is furnished by the use of two quadrilateral skin flaps pedicled on the margins of the defect and turned in and united in the midline, or the donor flap may be previously skin-grafted or doubled on itself (fig 131) As said before, for men the cover is best supplied by a scalp flap and for women by a forehead flap pedicled on one or both temporal arteries (83) The secondary wound left in the scalp is drawn together as much as possible, and

FIG 688. Use of buttress flap to elevate commissure. *A* defect. *B* steps of repair Dotted lines, incisions for removal of scar tissue and outline of flap Lower right figure, wound after excision of scar tissue. Lower left figure, wound sutured. Buttress flap used, to raise corner of mouth. *C* final result of operation. (Medical Dept., U S Army Vol. XI)

closure is completed by means of a skin graft. Scalp flaps carry a good blood supply and are particularly applicable where there are associated injuries about the cheeks, nose, and mouth, as the pedicle may be utilized in the reconstruction of these defects.

Padgett (72) cites an instance in which he replaced a total loss of the lower lip with a neck flap for lining and a scalp flap for cover (fig 690) Before the planned operation the neck flap was tubed and the scalp flap raised and resutured to its bed. At a second sitting two weeks later the neck flap was brought into the defect, skin side in, and covered with the scalp flap Three weeks later the pedicles were cut, fitted into the

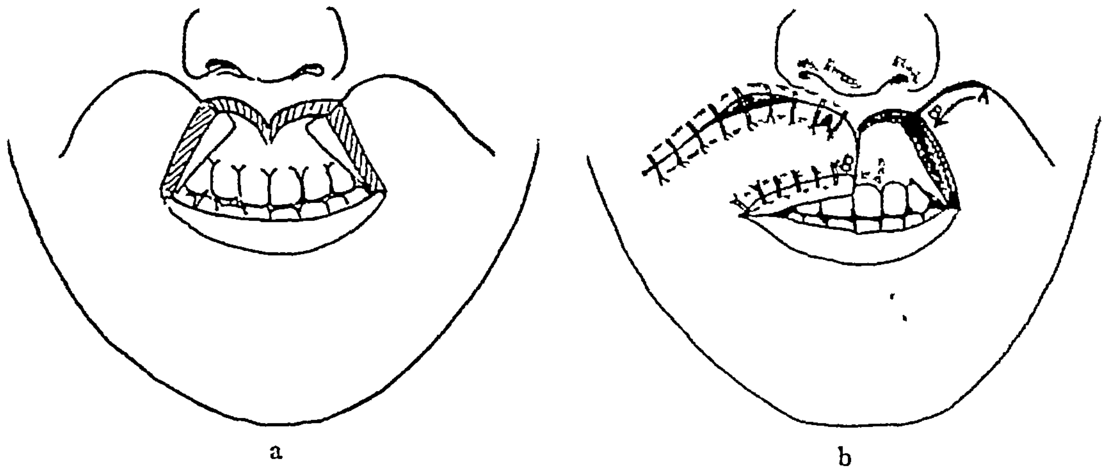


FIG 693 Repair of upper lip with descending flaps *a*, two nasolabial flaps carrying excess mucous membrane, raised *b*, flaps united in median line Excess mucous membrane turned over and sutured to skin, to replace vermilion border (von Bruns-Szymanowski)

FIG 694 Reconstruction of upper lip with scalp flap Flaps from cheek turned in and approximated, to form lining Double-pedicled scalp flap raised, to be used for cover (Cole)

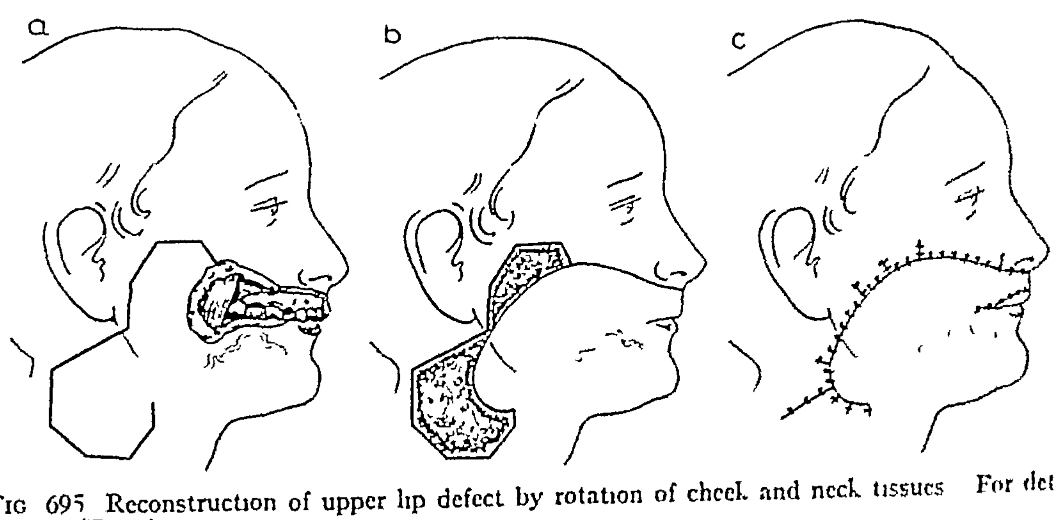


FIG 695 Reconstruction of upper lip defect by rotation of cheek and neck tissues For details, see text (Esser)

neck into the defect (fig 695) He writes My cuts for upper lip-cheek defects vary according to the size and place of the defect. They all have the same principle, that the arteria maxillaris externa lies in the center and the cut first rises, then makes a broken curve, passing under the ear and taking more or less of the neck, according to size of defect. The end of cut is always suddenly vertical, so as to make the whole movable. In some cases both cheeks are used, but mostly one side suffices, even for very large defects. After making the piece as movable as required, it is then turned and placed in the defect. The cut varies according to the presence or absence of hair, and if the defect also extends to the eyelid. Further, a somewhat similar cut is necessary in the mucous membrane of the mouth again commencing at the same place and in the same direction, but turning before reaching the ductus stenonianus. At the end of this cut is also a sudden perpendicular incision to facilitate its removal. The mucous membrane cut is not only important for the removal of the whole part, but also because the sewing together of the mucous membrane wound after the removal supplies a surplus to be used for the inside of the new lip The first part of the cut may split

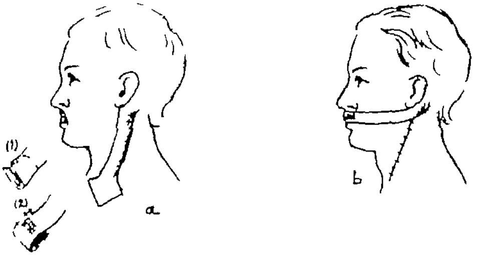


FIG. 696 Reconstruction of upper lip with cervical flap. *a* flap raised and tubed. Insert *1* lining supplied by ends of flap turned in Insert *2* lining supplied by skin graft on stent mold. *b* lower pedicle cut, and lined flap swung into defect. (New and Erich)

the entire cheek, but further on it must gradually be less deep for fear of injuring the facial nerve or the ductus stenonianus.

The reconstruction of an upper lip defect with a cervical flap is shown in Figure 696

REPAIR OF MINOR DEFORMITIES OF LIPS

Minor deformities of the lips may be congenital, due to defective closure of the mandibular and maxillary processes, or they may be secondary to cicatricial changes arising from burns, wounds and specific diseases, such as syphilis, tuberculosis, and noma.

MACROCHELIA

The term macrochelia is used to designate a variety of lesions characterized by an abnormal enlargement of the lip The hypertrophy is usually confined to the vermilion

border of one or both lips, giving the possessor a negroid appearance It occurs in various degrees, ranging from a barely perceptible increase in size to one so large as to produce an ectropion of the lip The deformity may be congenital, or it may be acquired as a result of *inflammations*—e g , lymphangitis, eczema, syphilis, and tuberculosis, tumors, such as hemangiomata and lymphangiomata (71), and endocrine disturbances, such as acromegaly Pathologically, it is marked by either a hypertrophy of the orbicularis oris muscle or by a hyperplasia of the submucous and glandular tissue Ascher (5) described a clinical entity comprising an abnormal increase in the

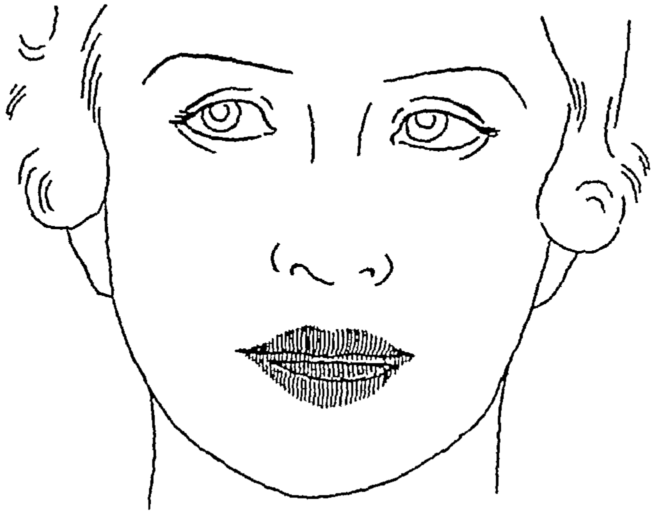


FIG 697 Correction of macrochelia of lower lip by excision of wedge-shaped section of hypertrophic tissue

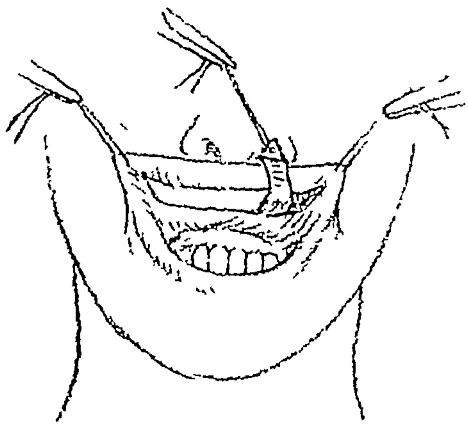


FIG 698 Correction of macrochelia of upper lip by excision of wedge-shaped section of mucous membrane, submucous tissue, and hypertrophied orbicularis oris Edges of wound approximated with on-end mattress-sutures of fine silk.

size of the lip, enlargement of the thyroid gland, and blepharochalasis, a condition which has since come to be known as Ascher's syndrome New and Kirch (70) in a report of 67 cases describe a condition distinguished by an enlargement of the lips and face secondary to recurrent swellings and facial paralysis They state: "Specimens of tissue were taken for biopsy in a few cases before treatment, but nothing was found other than edematous tissue containing lymphocytes"

Before an attempt is made at correction of this defect, the underlying etiologic factor must be determined and attended to

The deformity may be corrected by the following methods: (1) A transversely

placed wedge-shaped segment of mucous membrane, submucous tissue, and hypertrophied musculature of orbicularis oris is removed from the posterior aspect of the lip the base of the wedge extending across the mucosal surface of the lip from one commissure to the other and the apex dipping into the submucous tissue (figs. 697–698) Hemorrhage, which is likely to be profuse, is controlled by means of lip clamps. As a rule, one or two vessels will require ligation. After bleeding has been checked, the margins of the wound are united with interrupted on-end sutures of horsehair or fine silk (19, 51, 60) The part is painted with Whitehead's varnish no other dressing being required. The sutures are removed in 48 to 72 hours.

(2) A horizontal incision is made along the oral aspect of the mucosa of the affected lip from commissure to commissure. The mucosa is undermined above and below, and the excess submucous tissue is removed. The superfluous mucous membrane is then trimmed and the margins carefully approximated (31)

(3) For extensive hypertrophy associated with ectropion Joseph operated thus A wedge was removed from the posterior aspect of the lip, as described above A triangular segment with its base lying on the free margin was then excised from the

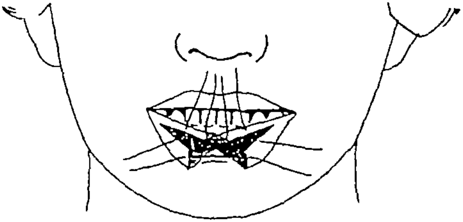


FIG 699 Joseph operation for extensive hypertrophy of lower lip associated with ectropion Wedge of tissue resected from posterior aspect of affected lip and additional triangular segments based on free margin of lip Sutures passed for approximation of raw margins

entire thickness of the central portion of the lip When the margins were united, the lip was found to be shorter and thinner, both the hypertrophy and the abnormal length having been overcome. Figure 699 is self-explanatory

Other forms of therapy, such as irradiation with radium or x ray and the injection of coagulating substances have been suggested for the correction of this condition, but surgical excision is on the whole the most satisfactory treatment.

Double Lip

Double lip is a type of hypertrophy usually limited to the upper lip and characterized by a groove running parallel to the oral aperture. When the mouth is closed, the lip appears doubled and when it is open, the lower segment hangs down as a redundant fold The exact cause of the condition is unknown, but it is probably due to a displacement of the fibers of the orbicularis oris muscle associated with a pouching of the mucous membrane due to hypertrophy of the glandular and submucous tissues.

The disfigurement can easily be corrected by any of the following methods (1) A

horizontal wedge-shaped section from 4 to 8 mm in width is removed from either side of the lingual surface of the lip, and a vertical wedge is resected from the central portion. The borders of each residuary wound are undermined for a distance of about 1 cm, and the hypertrophied submucous tissue is excised, care being taken to preserve the circulation and symmetry around the corners of the mouth. The wounds are then closed with interrupted sutures of fine silkworm-gut placed 2 to 3 mm. apart, each suture being made to incorporate a few fibers of the orbicularis oris muscle (41) (fig 700)

(2) With the upper lip everted by means of 2 or 3 traction sutures, an incision is made in the lip just above the gingivolabial sulcus, and the mucous membrane is undermined to the lip margin The excess submucous tissue is excised, the redundant mucosa trimmed, and the margins of the wound accurately coapted (42)

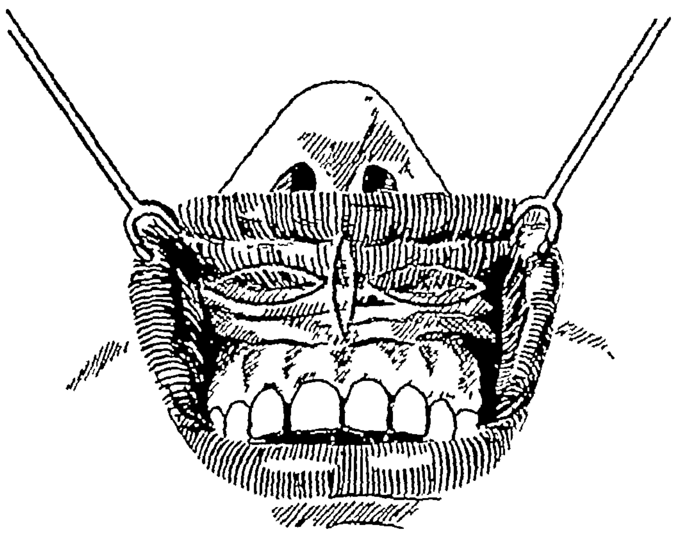


FIG 700 Correction of double lip Two horizontal wedge-shaped sections excised from either side of lingual surface of lip Vertical wedge removed from central portion, to prevent buckling Following resection, margins of residuary wounds mobilized, and hypertrophied submucous tissue excised Margins coapted with sutures of fine silkworm-gut, each suture incorporating a few fibers of orbicularis oris muscle (Passot)

ECTROPION OF LIP

Ectropion of the lip varies from a slight eversion to a complete turning out of the entire lip The deformity is occasionally congenital, but more often is acquired as a result of cicatricial contraction following severe burns about the chin, neck, and chest. The constant exposure of the teeth and gums consequent upon the eversion predisposes to dental decay, and the continual traction on the alveolar processes may, in the case of children, deform the mandible and interfere with its growth Aside from the disfigurement, the drooling of saliva and the interference with speech and mastication produce a most distressing condition The management will depend upon the causative factor and the degree of involvement.

A *slight eversion of the upper lip* may be corrected by a lengthening of the lip in its vertical dimension at the expense of its width A narrow elipse of tissue comprising the full thickness of the lip and with its long axis parallel to the oral aperture, is excised above the vermilion border, and the residuary wound is sutured vertically (8) Another method consists in the outlining of two triangular flaps with their apices meeting over the point of greatest contraction The flaps are mobilized, superimposed one

upon the other, and sutured in such a manner that the apex of each flap is directed toward the base of its fellow (92) (fig 701)

In *more severe cases* of labial ectropion the restricting scar tissue is excised and the lip brought down to its normal position. The raw area left after the removal of the scar is covered with a skin graft or a contiguous cheek flap

For the correction of *slight eversions of the lower lip* many operative procedures have been devised, based on the principle of the advancement flap (p 234) but except in the mildest degrees of ectropion these are rarely successful. An example of this type of operation is that of Jones (49) modified by Blasius (14), as follows The cicatrix is released by means of a V-shaped incision with its base directed toward the vermilion border The tissues are undermined for a distance sufficient to correct the eversion, whereupon the wound is sutured in the form of a Y or T, width being thus gained at the expense of length The principle of the operation is illustrated in Figure 524 The most satisfactory procedure consists in the removal of the scar, liberation of the lip, and covering of the raw surface with a skin graft or contiguous cheek flap

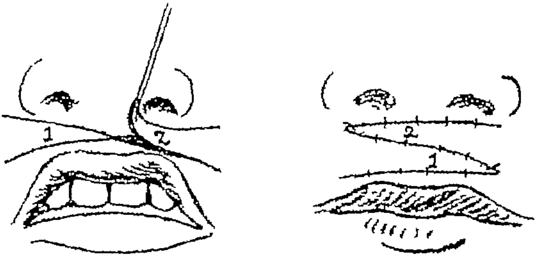


FIG. 701. Correction of eversion of upper lip by transposed flaps *a*, two triangular flaps outlined on upper lip, their apices meeting over point of greatest contraction. *b* flaps mobilized, superimposed and sutured to each other thus lengthening lip in vertical dimension at expense of width. (Teale)

Entropion of Lip

Entropion of the lip is usually due to a cicatricial shortening of the mucosa following trauma, burns, syphilis, or tuberculosis. Before the lip can be made to assume its normal position, the tension of the cicatricial bands must be released and the lost mucous membrane replaced.

The lip is everted by means of 2 or 3 traction sutures passed through its substance, and all scar tissue, irrespective of its extent is carefully removed. The raw area is then skin-grafted on a mold, after the method of Esser (34) A piece of stent on a tray is covered with a thin razor graft, raw surface out, applied to the denuded area, and secured in place by means of a cap-splint previously attached to the teeth Additional pressure is obtained from an elastoplast bandage laid across the lip At the end of 10 days when the mold is removed the area will be found epithelized. As a precaution against subsequent contraction of the epithelized area, a prosthesis is worn for 2 or 3 months.

Abnormally Narrow, Abnormally Straight, or Irregular Vermilion Border

An abnormally narrow vermilion border and irregularities along the mucocutaneous junction usually follow a faulty cleft lip repair, although occasionally these defects arise as a result of trauma

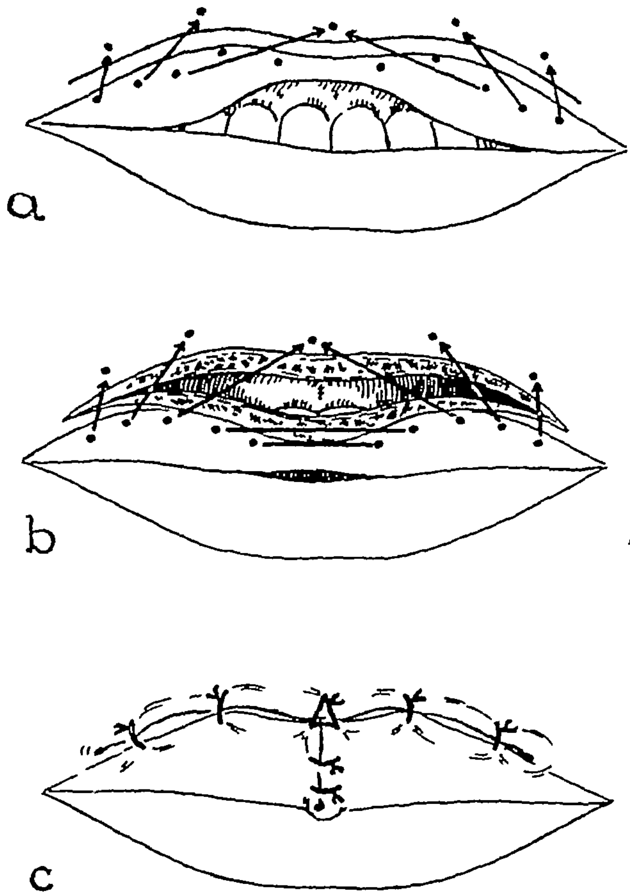
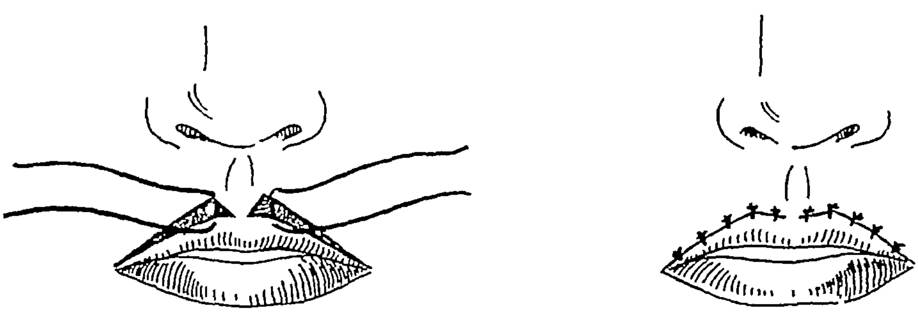


Fig 702 Reconstruction of irregular vermilion border associated with ectropion of central portion of upper lip *a*, red line indicates incision along proposed vermilion border Arrows show direction toward which mucosa is to be shifted *b*, incision made through full thickness of lip, and vermilion border drawn down to proper level *c*, wound margins approximated in direction of arrows (Wolff)



a b

Fig 703 Reconstruction of irregular vermilion border by creation of new curve at higher level. *a*, triangle outlined in center of lip, its base representing highest level of new vermilion border Two triangles of skin resected from either side Lower lip of wound dissected from orbicularis muscle for a few millimeters *b*, mucosal flap drawn up and approximated to skin margin of wound with fine horsehair or ophthalmic silkworm-gut For details, see text (Gillies)

If there is no shortage of tissue, correction can be accomplished by separating the existing vermilion border, undermining the mucosal flap, and shifting it into a lower position on the lip Figure 702 is self-explanatory.

Gillies (43) discards the mucocutaneous border already present and creates a new curve at a higher level, a procedure which he terms the "Cupid's Bow Operation" (fig 703) A triangle is outlined in the center of the lip, its base representing the highest level of the new vermilion border From either side of the base an incision is made sloping toward the angle of the mouth, the amount of sloping depending upon the curvature desired An incision is now made along the existing mucocutaneous border The lower lip of the wound is dissected from the orbicularis muscle for a few millimeters, some of the tight lowermost fibers being divided to obtain the necessary relaxation All irregularities are trimmed away from the mucosal flap The skin between the upper and lower incisions is excised The central triangular section previously outlined is left intact. The mucosal flap is now drawn up and carefully approximated to the skin margin with fine horsehair or ophthalmic silkworm-gut. The part is dressed with a layer of Whitehead's varnish The sutures are removed in 3 days.

Faulty cleft lip operations frequently result in asymmetry of the two halves of the lip, due to an inequality of the vertical lengths. In such cases the original scar is removed and the two sides are adjusted according to one of the methods outlined in the section dealing with cleft lip deformity

Flat Lip

Flatness of the upper lip may be due to a loss of foundation or to an insufficiency of labial tissue causing the soft parts to be stretched too tightly over the maxillary arch In the former case the condition is usually congenital and forms a part of the so-called cleft lip profile, the lack of foundation being consequent upon displacement necrosis, or removal of the premaxillary support. Less commonly, the deformity results from a fracture of the alveolar arch with backward dislocation, or from operative removal of a portion of the maxilla.

When the foundation is at fault, building out of the defect by means of a cartilage or bone graft is out of the question, owing to the septic nature of the oral cavity When there are sufficient teeth in the jaw and the buccal sulcus is deep enough, the flatness may be overcome by attaching to the teeth a prosthesis carrying a support designed to hold the soft parts at the proper projection. If the sulcus has been obliterated, it must first be reconstructed before the appliance can be introduced The technic is detailed on page 1072

When the flatness is the result of a deficiency of the soft structures, tissue may be added by one of the methods detailed in the section on lip reconstruction following loss of tissue, the most satisfactory being the procedure of Estlander Abbe.

Abnormally Long Lips (Macrostomia)

Abnormally long lips result from a defective union between the mandibular and maxillary processes and constitute the condition known as macrostomia Plastic operations designed for the correction of this deformity usually fall short of satisfaction as the residuary scars are likely to be as disfiguring as the original condition. Shortening may be accomplished by the removal from either lip, just medial to the commissure, of two quadrilateral sections of full thickness tissue and of such a size that when the wound margins are united, the mouth will be of the proper dimensions.

The mucosa and muscle of the two contiguous raw areas are approximated with catgut as one layer, and the skin is carefully sutured with horsehair

Davis (24) suggests that the condition be corrected by means of a "V-shaped incision on each side through the full thickness of the cheek at the proper distance from the angles The apex should be outward and on a level with the commissures. The triangular flap between the legs of the V is then shifted toward the median line, and the wound is sutured in the shape of a Y In marked cases, whether congenital or acquired, it is necessary to separate the tissues and suture them in layers—mucous membrane to mucous membrane, etc Great care should be taken to line the newly constructed commissures with mucous membrane or skin "

Joseph (51), in an effort to eliminate scarring in the vicinity of the commissures, advocated the excision of two vertical strips of tissue from the upper lip on either side of the philtrum and the removal of a section of tissue from the central part of the lower lip (fig. 704)

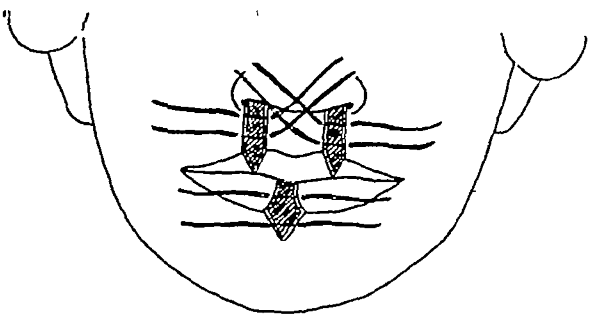


FIG 704 Joseph operation for correction of macrostomia Vertical strips of tissue excised from either side of philtrum and from central part of lower lip Sutures passed for approximation of wound margins

ABNORMALLY SHORT LIPS (MICROSTOMIA)

A diminution in the length of the lips results in stenosis of the oral aperture The condition is occasionally congenital, but more often it is due to cicatrization following tuberculosis, syphilis, noma, epithelioma, burns, and other forms of trauma The destruction of tissue may be limited to the skin or mucous membrane or may involve all the structures of the lip The narrowing may be negligible or so considerable as to prevent the introduction of solid food, interfere with the function of speech and mastication, render difficult attention to oral hygiene, and prohibit the insertion of an artificial denture when necessary

The simplest, although not the most practical, method for the correction of this deformity is the following Through the entire thickness of the cheeks two incisions are made, extending horizontally outward from the commissures of the contracted mouth for a distance sufficient to obtain an opening of the proper size To facilitate approximation of the skin and mucosa, a trough of subcutaneous tissue is removed from the wound margins, and to allow rolling out of the mucous membrane, a few millimeters of skin around the lip margins are excised The oral mucosa adjacent to the defect is then undermined and rolled over to meet the shortened skin margin, to which it is accurately sutured

Von Langenbeck (58) enlarged the aperture by a procedure based on the principle of the Y-V advancement flap (fig 705) At the corners of the mouth Y-shaped incisions were made, down to but not through the mucous membrane, the short limbs enclosing

the commissure. Incisions were then made through the angles of the mouth, sufficiently long to assure an opening of the required size The Y-shaped wounds were closed in the form of a V, and the raw margins were covered with mucosal flaps taken from the lips and cheek

A more satisfactory operation is that of a Dieffenbach (27) (fig 706) A triangular section of skin and subcutaneous tissue is removed from either commissure, the size

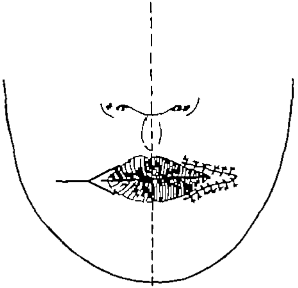


FIG 705 Correction of microstomia by Y V advancement flap Y-shaped incision outlined on right side. Mouth angle extended by horizontal incision. Operation completed on left side. Wound closed in form of V by uniting mucosa to skin (von Langenbeck)

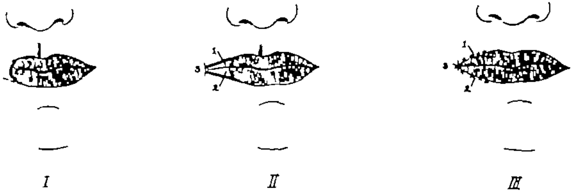


FIG 706 Dieffenbach operation for correction of microstomia limited to one side. *I* triangle of skin and subcutaneous tissue to be excised outlined by dotted line. *II* underlying mucous membrane bisected horizontally to point just short of proposed commissure. Mucosal flap outlined at apex of triangle, indicated by dotted line. *III* upper and lower flaps *1* and *2* turned out and sutured to corresponding skin margins. Lateral flap *3* carried over and sutured to outer cutaneous margins to form new commissure. (Blair)

of the section depending upon the enlargement required. The underlying mucosa is bisected horizontally to a point just short of the proposed commissure and at the outer ends of the horizontal incision a vertical arched incision, convex medially, is made. Thus three mucous membrane flaps are outlined at the corner of each lip—an upper a lower and a lateral. The upper and lower flaps are turned out and carefully sutured to the corresponding skin margins and the lateral flap is carried over and sutured to the outer cutaneous margins to serve as the new commissure. It is es-

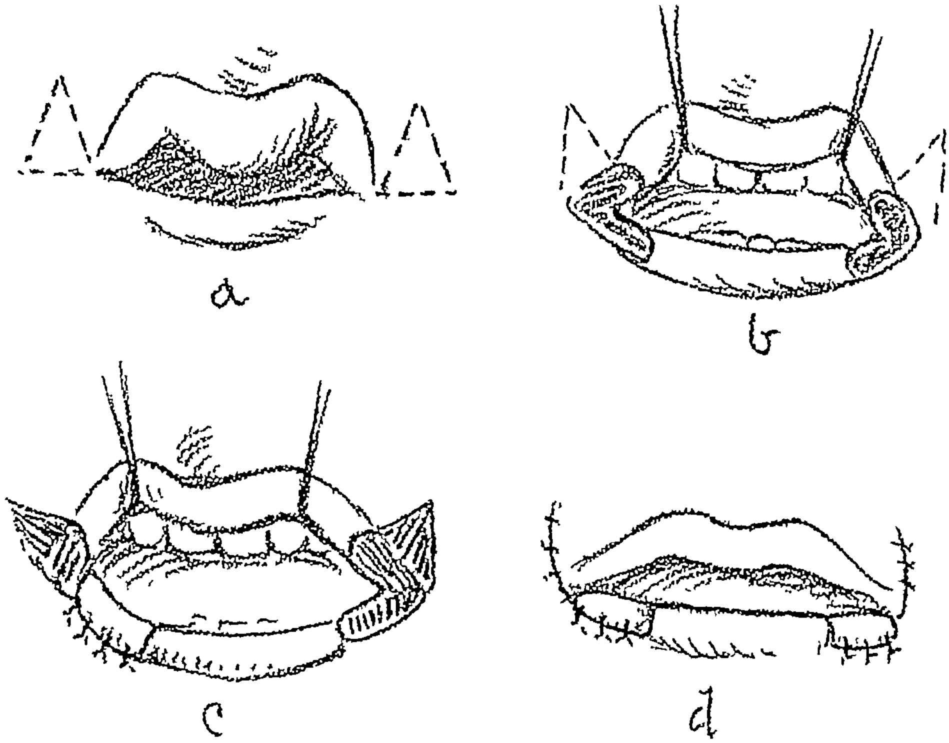


FIG 707 Elongation of lower lip *a*, triangles outlined with their bases on line of oral aperture *b*, base of triangle incised through full thickness of cheek *c*, skin within triangle excised Mucous membrane of lower lip brought forward and sutured to skin margin *d*, triangles at corners of mouth closed (Swinton and Trommald)

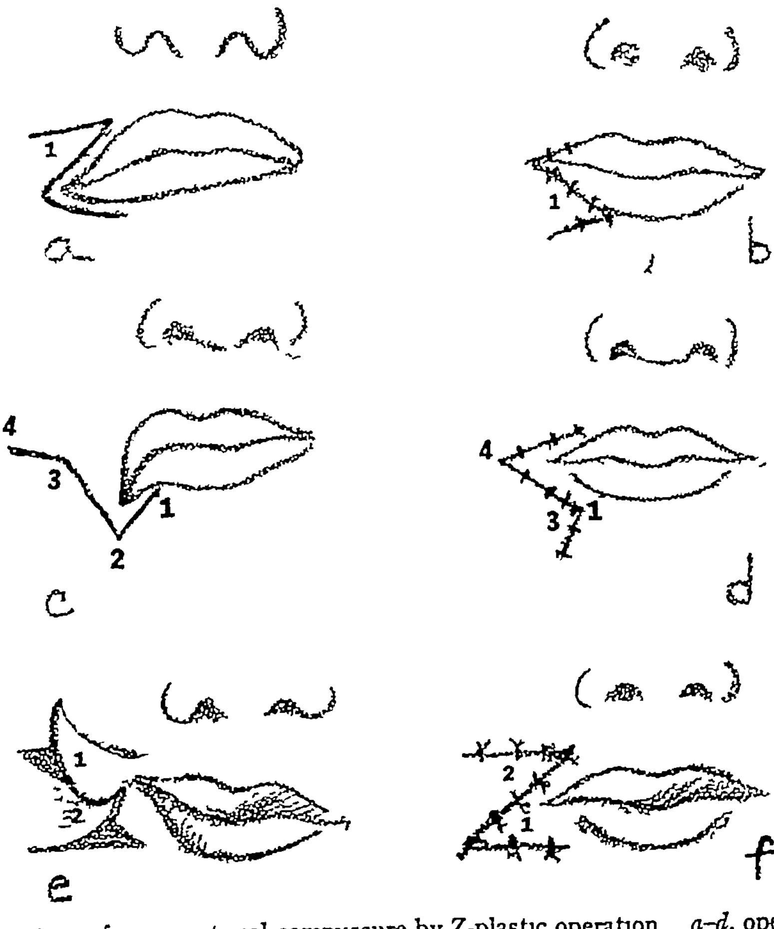


FIG 708 Correction of asymmetrical commissure by Z-plastic operation *a–d*, operations designed to raise angle of mouth, *e–f*, operation to lower angle.

sential that the skin and mucous membrane be joined accurately especially at the commissures, otherwise, primary union will fail to take place, and the deformity will reappear

In the case of undue shortness of the lower lip, a simple procedure to effect its elongation is that of Swinton and Trommald (88) (fig 707) At either commissure a triangle based on the line of the oral aperture is outlined and its base incised throughout the full thickness of the cheek The skin within the previously outlined triangle is removed The oral mucous membrane of the lower lip along the lines of incision is undermined, turned out over the raw surface, and sutured to the skin. The triangular wounds remaining at the commissures are closed by direct approximation of their margins.

Asymmetry of Commissures

Asymmetry of the commissures may be paralytic, due to injury of the facial nerve, or cicatricial, following ulcerations, burns, or wounds. The correction of the paralytic condition is discussed in the section dealing with facial paralysis (p 1012) In the cicatricial form correction can usually be accomplished by recourse to Bayer's (7) Z-plastic operation. A Z-shaped incision is made just beyond the displaced commissure, and the flaps are transposed in such a manner that the angle of the mouth will be drawn up or down, as desired. Figure 708 is self-explanatory

CARCINOMA OF LIP

The mortality from carcinoma of the lip as compared with that from carcinoma elsewhere is relatively low Because of the exposed site of the lesion patients present themselves early for relief, the characteristic appearance of the growth eliminates diagnostic difficulties, histologically, the cells are of a low grade malignancy, metastases are limited chiefly to accessible areas in the upper region of the neck and the anatomic situation of the growth and the distribution of the lymphatic channels and nodes are such as to permit of complete eradication with a minimum of shock and without serious disturbance of function. Nevertheless, largely as a result of ignorance, procrastination and ill advised attempts at self treatment, lip cancer exacts an annual toll of 7000 lives in the United States alone (94) While carcinoma of the lip usually occurs after middle life, the average age being 58.5 years (37, 98), it may attack the young and, as in the case of cancer in other parts of the body the more youthful the individual, the more rapid the growth, the earlier the involvement of the lymph-nodes, and the graver the outlook It is at least 20 times more common in men than in women (32, 47, 53 96) In Figi's (37) series of 942 cases only 11 patients (1 15 per cent) were females, whereas 931 (98 9 per cent) were males. It is 20 times more frequently encountered in the lower lip than in the upper, where it usually takes the form of a rodent ulcer and is often only locally malignant. In 425 cases of carcinoma of the lip reported by Wile and Hand (96) 93.3 per cent affected the lower lip, 4 7 per cent the upper lip, and 2 per cent the commissures As in cancer elsewhere chronic irritation is a predisposing factor, although in many instances no such history is obtainable The most common source of irritation is smoking the lesion occurring at the site where the pipe or cigar rests on the lip Other causes responsible for the condition are fissures, leukoplakia, inflammations, faulty dentures, and exposure to the sun's rays.

Clinical Varieties. Clinically, two types of lip cancer are recognized (1) *a papillary form* and (2) *an ulcerative form* The papillary variety is the most common Histologically, it belongs to Groups 1 and 2 of Broder's classification of carcinoma based on the cell type—i e, the more highly differentiated the tumor cell the less malignant the growth (96). In Figi's (37) series of lip cancer cases 85 24 per cent were of the papillary type, 33 01 per cent being of Grade 1 and 52 23 per cent of Grade 2 This form of cancer is of a low order of malignancy, remains localized for a long time, and responds to conservative treatment It begins either as a keratosis or as a small erosion at the mucocutaneous junction, usually to one side of the midline It spreads slowly, infiltrating the deeper tissues In time ulceration takes place, followed by metastasis to the regional nodes The ulcer shows only slight induration, a shallow base, and slow progression with a tendency to heal, break down, and heal over again

The ulcerative type falls into Groups 3 and 4 of Broder's classification Figi's (37) series shows 12 84 per cent of Grade 3 and 1 91 per cent of Grade 4 This form of lip cancer is more malignant and offers a less favorable prognosis than does the papillary variety It may start from a fissure, a minor injury, or a chronic ulcer, or it may originate as a nodular subepithelial mass Ulceration begins early, the borders of the lesion being elevated and markedly indurated It has a tendency to metastasize to the cheek, gums, upper lip, floor of the mouth, periosteum, and mandible There is early involvement of the lymphatic nodes The submental and submaxillary are the first to be affected; from here the spread continues to the deep cervical nodes

The diagnosis is confirmed by microscopic examination In the presence of palpable nodes an aspiration biopsy is made to determine whether the enlargement is due to inflammation or metastatic emboli (Blair (11), however, believes "aspiration of a potentially cancerous node to be absolutely unsurgical, that a negative microscopic finding would be without meaning, and that the procedure itself is not without grave risk to the patient if the gland is cancerous ") At the time the section is removed, a pathologist should be present to make an immediate diagnosis, and the surgeon should be prepared to carry out the necessary steps for the eradication of the growth, should it prove malignant

Management

The manner of dealing with malignant lesions of the lips has within recent years become a matter of controversy The advisability of the former routine radical extirpation of the primary growth together with its regional metastases no longer remains unchallenged, owing to the gratifying results which have followed treatment by irradiation, especially since the introduction of Coutard's (22) method of fractionating and protracting the total dosage over a long period Many clinics today use irradiation solely and claim successes equal to or surpassing those of surgery But a true estimation of the comparative merits of surgery and irradiation as evidenced by statistical data can hardly be made, in view of the wide variety of clinical material upon which the reports are based

At present carcinoma of the lip is treated by surgery, by irradiation, and by a combination of the two The difficulty is to decide which offers the best prognosis in the particular case, and this can be ascertained only by a study of many factors, among which are the age and general condition of the patient, the duration, location, and size

of the lesion the extent of infiltration, the presence or absence of palpable nodes, the type of cancer cell, the presence of infection, the condition of the surrounding tissues, and the facilities available for treatment. In view of the multiple considerations that enter into the problem, the best interests of the patient will be served if the radiologist pathologist, and surgeon enter into consultation

In the treatment of carcinoma of the lip two problems present themselves (1) *the care of the primary lesion,* and (2) *the management of the cervical nodes*

Treatment of Primary Lesion

(1) **Precancerous Lesions.** All lesions about the lips, such as ulcers keratoses, fissures, leukoplakia, and cutaneous horns showing a tendency to induration or chronicity, especially in patients of cancerous age, are deemed potentially malignant and should be destroyed. Under local anesthesia the whole area is excised for a considerable distance beyond the pathologic tissue either with a scalpel or with an electro-cutting knife (fig 709) This procedure not only eliminates the precancerous lesion, but also provides a specimen for microscopic study In lieu of excision, the area may be destroyed by cauterization with an actual cautery or by electro-desiccation, going well into the healthy margin The objection to the latter methods, however is that they render the tissue unsuitable for microscopic examination.

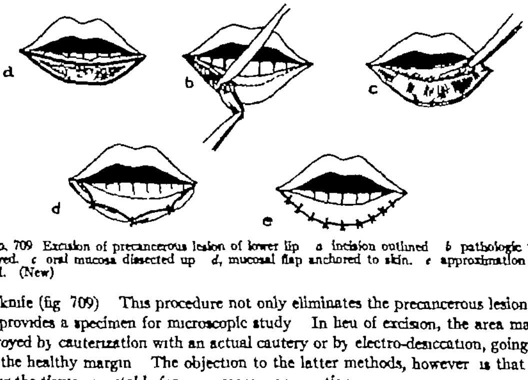


FIG. 709 Excision of precancerous lesion of lower lip *a* incision outlined *b* pathologic tissue removed. *c* oral mucosa dissected up *d*, mucosal flap anchored to skin. *e* approximation completed. (New)

(2) **Early Superficial Lesions** In early superficial lesions of Broder's Types 1 and 2 which do not exceed 2 cm. in diameter or 6 mm. in thickness, show no evidence of muscular or glandular infiltration and have not undergone ulceration, any method capable of eradicating the growth—whether irradiation cauterization, or surgery—may be employed *Irradiation therapy* is usually favored if the lesion has spread over a considerable area of the lip or is in the vicinity of the commissures as the cosmetic result will be superior to that following surgery Owing to the sensitivity of the cancer cell and the relatively greater resistance of the unaffected tissues, irradiation will destroy the growth without infringement upon normal tissue whereas excision would necessarily entail the sacrifice of a good margin of healthy tissue, with consequent deformity The strongest objection to irradiation is the protracted treatment expense and discomfort to the patient

For early growths which have not progressed much beyond the stage of keratosis Martin (64) advocates the use of the unfiltered radon bulb in doses ranging from 400 to 1000 millicurie minutes, depending upon the extent of the lesion "This applicator consists of a thin glass bulb about 5 mm in diameter, containing 200 to 500 millicuries of radon, which is held in contact with the lesions by a special holder for a few seconds or minutes, depending on the desired dose . For superficial lesions which are more advanced than the above, and whose thickness is not more than 3 to 4 mm , we use contact application of filtered radon Filtered radon tubes are held in contact with the lesion of the lip in a moulage of dental modeling compound [fig 710] Holding the moulage next to the patient's lip and guided by inspection of the growth, an outline is scratched so as to encircle the imprint of the lesion by a margin of at least 5 to 6 mm The applicator is then ready for the placement of the radon tubes These radon tubes are 1 6 cm in length with a wall thickness of 0 5 mm of platinum and contain glass tubes of radon Their individual strength will vary from 25 to 75 millicuries

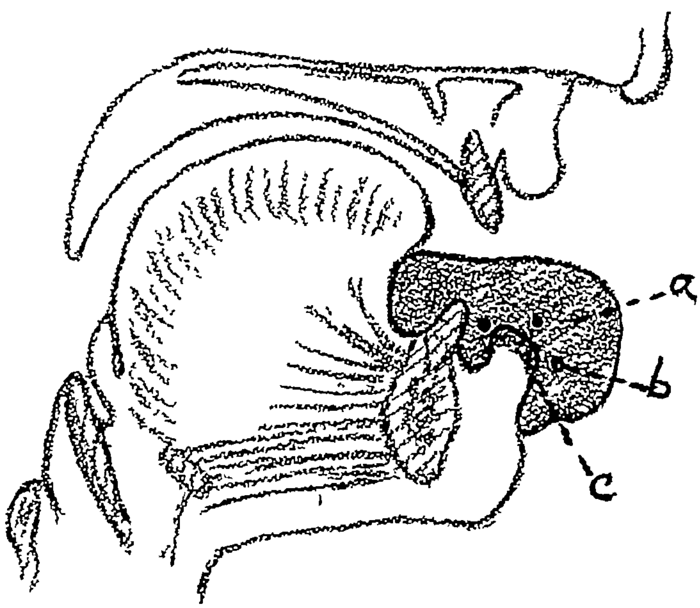


FIG 710 Moulage for holding filtered radon in contact with lip *a*, dental compound *b*, filtered radon tubes *c*, tumor For details, see text (Martin)

each If a number of short radium element needles are available, they may be substituted for the radon tubes just described

"With a hot metal die of the same size as the radon tubes, grooves are made within the outlined area so that the radon tubes, when placed, will lie from 4–6 mm. apart, and about 1–2 mm below the surface of the mold Their position is so arranged that they are distributed as evenly as possible over the surface of the lesion, and produce as much cross-firing as possible The tubes are sealed in place by melted paraffin The area to be irradiated (that inscribed by the scratch mark surrounding the lesion) is then roughly calculated in square centimeters If the area is small (up to about 3 sq. cm) about 85–90 mc hr per square centimeter are given. The minimum total dose ever given with this applicator should be at least 240 mc hr. with three tubes Moderately thicker lesions should receive higher doses per square centimeter. If the area to be treated is 5–6 sq cm or more, the dose per square centimeter should be decreased to 70–80 mc hr per square centimeter (350–500 mc hr total), because of the cross-firing from the several tubes"

Platinum radium needles may be used in place of radon tubes. These are employed by Fox (40) who uses 1 mg of radium to each running centimeter of needle The needle is introduced beneath the border of the lesion and left in place from 5 to 7 days, each needle thus producing approximately 100 mg hrs. X-ray may also be used, 2 skin erythema doses (680 roentgens) being employed on alternate days for 4 or 5 doses.

If the *cautery* is used to destroy the growth, it is heated to 1200 to 1500°F Percy (75) determines the proper temperature of the cautery knife by thrusting it into tincture of green soap for a distance of 1 cm., at a temperature of 1200 to 1500°F it will not hiss when entering the soap nor stick when being removed

Surgical excision is preferable if the lesion shows considerable induration The operation may be done under local anesthesia. The lip is everted by two silk tractor sutures With a scalpel or high frequency cutting current the cancerous tissue is excised through the full thickness of the lip in the form of an arched V the dissection extending at least 1 cm. beyond the palpable margins of the lesion The arching of the limbs of the V will permit of approximation without shortening of the vertical length of the lip (fig 677) Following the excision the coronary arteries are ligated and the raw surfaces cauterized with a thermocautery as a precaution against transplantation of cancer cells which may have escaped removal. Before the wound is closed, the tissue is submitted to microscopic examination. If the lesion shows a high grade of malignancy the submental and submaxillary glands are resected at the same sitting (p 1104) If it is found to be of a low grade malignancy, as is usually the case, the residuary defect is closed immediately The size of the wound permitting, the margins are approximated in layers, the mucosa being united with interrupted silk sutures, the muscle with 1 or 2 mattress-sutures of #000 chromic catgut, and the skin with #0000 silkworm-gut. The sutures are removed in 4 or 5 days. The resultant scar is usually inconspicuous. When the excision has been so extensive that direct closure of the wound would result in undue shortening of the lip the defect may be reconstructed in accordance with one of the methods detailed on page 1076

(3) **Bulky Lesions.** In bulky, deeply infiltrating tumors surgical excision of the growth together with the tributary lymphatics is preferable to eradication of the growth by irradiation since the dosage of irradiation required to destroy such lesions would necessarily be so powerful (8 to 10 S.E.D) as to result in a destruction of tissue, calling for plastic operations as extensive as if surgery had been used from the start Furthermore should irradiation fail, it may close all doors to subsequent therapy by leaving the tissues unresponsive to further irradiation and unfit for surgery, whereas if surgery is tried without success, subsequent irradiation treatment is hampered but slightly, if at all. In these cases it may be of advantage however, to employ irradiation preoperatively, for by such a procedure the virulency of the tumor can be reduced and the danger of surgical dissemination of the cancer cells diminished, and in consequence a less radical excision will be required, the amount of mutilation minimized, and the mortality decreased In some cases such preliminary treatment makes it possible to operate on tumors originally considered inoperable. Used postoperatively, however, irradiation is of questionable value Inasmuch as the destructive action of the rays is not dependent upon the quantity of cells but rather upon their sensitivity, it is reasonable to assume that if the cancer cells were originally radiosensitive, they would have been destroyed by preoperative subjection to the rays, making postopera

tive application unnecessary On the other hand, if they were originally radioresistant, any subsequent irradiation would obviously be ineffectual

Following the excision of these bulky growths the advisability of carrying out a primary or a secondary repair must be considered In cases where sufficient tissue has been removed to give a reasonable assurance of non-recurrence and the patient's condition permits, immediate repair is the ideal procedure, since there is neither scar tissue nor distortion to interfere with closure But if the loss has been so great as to require the transfer of tissue from a distance, or if there is danger of recurrence, reconstructive procedures must be deferred for 6 months to a year If the bone has been cauterized, repair is delayed until after sequestration has taken place During the interval the skin is sutured to the mucous membrane, and a prosthesis is worn to prevent distortion of the tissues

Technic of Removal The operation devised by Martin (63), a modification of Bernard's (10) method, permits of a wide removal of the growth together with the submental and submaxillary lymph-nodes, and furnishes a satisfactorily functioning new lower lip The chief drawback of the procedure is its failure to permit of extensive neck dissection The operation contemplates excision of a rectangular segment of the lip and closure of the area by means of two lateral cheek flaps mobilized from the mandible The lip is lengthened in a horizontal direction by the removal of two triangles from above and lateral to the angles of the mouth, as advocated by Burow (79), the mucosa being conserved and reflected forward and sutured to the skin to form the vermilion border of the new lower lip The details of the procedure are given on page 1078

Should the growth be of such a nature as to require extensive neck dissection, the operation advocated by Stewart (87) is ideal While in most respects it is similar to that of Martin (63), it permits of a somewhat wider exposure of the cervical nodes As a precaution against infection of the neck wound from oral secretions, the cervical nodes are dealt with before the primary lesion The technic is as follows (fig 711): An incision is made just below the mandible from one angle to the other, penetrating the skin and platysma muscle The tissues are dissected down in the form of a flap as far as the thyroid cartilage, and at this level all structures are divided down to the muscle All loose connective tissue and lymph-nodes are elevated in the form of a flap The facial artery and vein are ligated The submaxillary gland on either side is dissected free and raised with the flap An incision is now made on each side of the primary growth, going well into healthy tissue, and carried down to the transverse incision already made The lateral flaps are separated from the jaw, the knife being held close to the skin at the lower part, in order to avoid the lymphatics Finally, the intervening central mass is loosened from the jaw and removed The mass is composed of the tumor with its overlying skin, the deeper tissues attached to the lymph-nodes of the neck, and the submaxillary glands held together by means of loose tissue which contains the connecting lymphatics.

In cases in which not over 2 cm. of the vermilion border of the lip has been resected the wound is approximated directly and drainage of the submaxillary fossa is instituted Following a more extensive removal the mouth is broadened by a horizontal incision extending outward from both commissures, the incision being carried down to, but not through, the mucous membrane The mucosa is cut at a level of 12 mm above the skin incision, to be used later to form a new vermilion border for the lower

lip To equalize the length of the lips, triangles are removed just above and lateral to the commissures as previously described. The new chin is sutured to the soft tissue over the lower jaw to prevent the seepage of fluid from the mouth into the neck wound

If the mandible is involved, the affected bone is either destroyed by electrocoagulation, cauterized with an endotherm button or the segment resected with a motor driven saw The *mucous membrane is sutured to the skin* and the wound left open A prosthesis is inserted to prevent distortion of the soft parts. At a later date after sequestration has taken place and the danger of recurrence has passed, the lip is reconstructed, and when the parts have healed in, a supportive structure is introduced

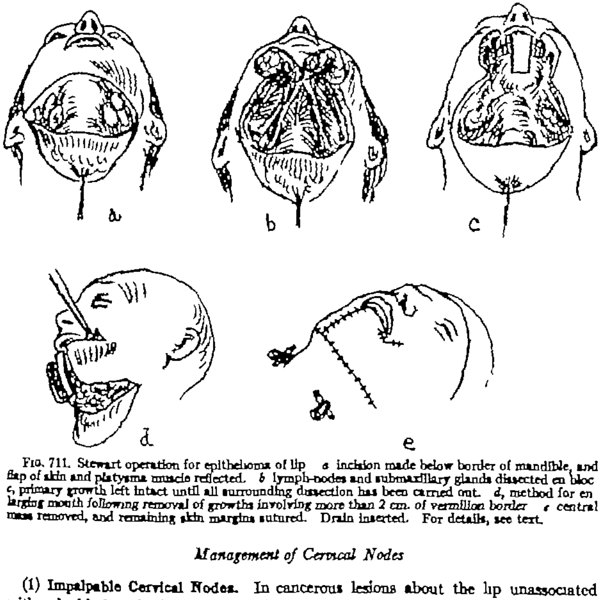


FIG. 711. Stewart operation for epithelioma of lip *a* incision made below border of mandible, and flap of skin and platysma muscle reflected. *b* lymph-nodes and submaxillary glands dissected en bloc *c*, primary growth left intact until all surrounding dissection has been carried out. *d*, method for enlarging mouth *following removal of growths involving more than 2 cm. of vermilion border* *e* central mass removed, and remaining skin margins sutured. Drain inserted. For details, see text.

Management of Cervical Nodes

(1) **Impalpable Cervical Nodes.** In cancerous lesions about the lip unassociated with palpable lymphatic nodes there is an irreconcilable difference of opinion among oncologists as to the advisability of prophylactic nodal resection at the time of the eradication of the primary growth.

Those opposed to prophylactic nodal resection feel that eradication of the initial growth, supplemented by irradiation of the neck and careful prolonged observation of the patient, offers as good results as routine removal of the nodes. They call attention to the fact that in fully 80 per cent of lip cancers metastases do not take place. Thus

the routine excision of impalpable nodes in all cases of carcinoma of the lip would subject 80 per cent of the patients to unnecessary neck dissection, which in itself carries a considerable operative hazard, an average mortality of 5 per cent following such resection having been reported by Kennedy (54) They further point out that nodal excision does not guarantee against recurrence, and should the nodes become palpable after removal of the primary lesion, they can still be resected with a fair chance of recovery Quick (78) states. "It is our belief that as satisfactory and successful an operation could be done after a node became palpable as before" Finally, they argue that up to a certain point lymphatic nodes perform a conservative function by acting as filters for the malignant emboli and thus serve as protective mechanisms Trueblood (94) stresses the diagnostic value of these nodes and writes· "If we believe that cancer emboli leave their original source and plant themselves in the nearest gland or glands draining that area, it must be inferred that these glands if still present, by reason of their invasion, offer fairly early evidence that the disease has extended so far If they have been removed routinely, this early evidence of continuation of the process even though the primary lesion may show no recurrence—is lost"

Those who favor prophylactic nodal resection feel that one has no right to assume that impalpable glands are not infected, or that malignant cells do not lie dormant in them, since apparently unaffected nodes frequently reveal secondary deposits Kennedy (54) showed an actual involvement in 14 per cent of impalpable nodes following prophylactic dissection The proponents bolster their arguments with statistics showing that routine prophylactic removal of the cervical lymph-nodes results in 10 to 40 per cent more "cures" than parallel groups in which no dissection is resorted to (40) Blair (13) states: "Our practice is not to examine a neck in carcinoma of the lip with the idea of excluding the neck dissection, because, if the patient is physically fit for the operation, we do a radical neck dissection in practically every proved squamous cell carcinoma of the lip"

While "no one has apparently as yet been able to devise a rationale of procedure plausible enough to satisfy all the observers," (94) the trend at present is toward conservatism If in the absence of palpable nodes the lesion is small, belongs histologically to Grades 1 or 2, is of recent origin, and shows no evidence of deep infiltration or ulceration, the initial growth is eradicated and prophylactic neck dissection omitted, provided the patient can be observed over a prolonged period The value of prophylactic irradiation in such cases is difficult to assess, since if cancer cells are absent in the nodes, irradiation is obviously uncalled for, and if they are present, it is generally admitted that the dosage usually prescribed is insufficient, inasmuch as from 7 to 12 erythema doses are required for the destruction of the cancer cell (65) Nevertheless, irradiation is advocated on the grounds that it will increase the resistance to metastasis and incarcerate the cancer cell either by blocking the lymphatic channels or by inducing fibrosis The lymph-bearing area is subjected to external irradiation therapy in the form of either x-ray, radium packs, or a combination of the two, in doses of such intensity as to deliver 2 to 3 skin erythema doses Stewart (87) employs a full skin erythema dose of high voltage Roentgen therapy to each side of the neck, and repeats the procedure after an interval of 6 weeks The patient is instructed to report for observation every month for the first year, every 2 months for the second year, every 3 months for the third year, and every 6 months thereafter for the duration of his life (54, 55).

Should evidence of lymphatic enlargement appear, surgical removal is carried out at once.

If the patient cannot be kept under observation, if there is considerable infiltration, or if the histologic examination shows the carcinoma to be of Grade 3 or 4, a neck dissection is carried out at the time of the eradication of the initial lesion If the growth does not approximate the midline the nodes on the affected side of the neck are removed en bloc, if it is near the midline, the dissection is made on both sides. In the absence of palpable glands the majority of surgeons (6, 29, 36, 37 38 39 50, 54, 55 76, 86) limit the dissection to the submaxillary and submental nodes since

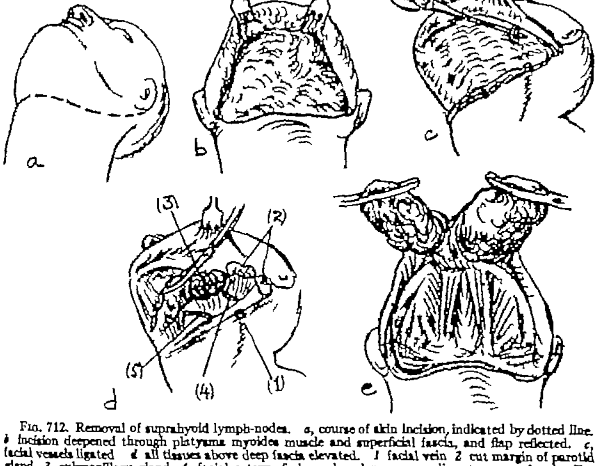


Fig. 712. Removal of suprahyoid lymph-nodes. *a*, course of skin incision, indicated by dotted line. *b* incision deepened through platysma myoides muscle and superficial fascia, and flap reflected. *c*, facial vessels ligated *d* all tissues above deep fascia elevated. *1* facial vein *2* cut margin of parotid gland *3* submaxillary gland, *4* facial artery *5* hypoglossal nerve. *e*, dissection completed. For details, see text. (Fischel)

extension of the malignant process through the lymph vessels to the deep cervical nodes rarely occurs. According to Figi (37) removal of the cervical nodes along with the submental and submaxillary groups is scarcely justifiable as a routine procedure." Should the dissected nodes show evidence of metastasis the block dissection is continued to the omohyoid on one or both sides, depending upon the location of the initial growth. Under such circumstances the excision includes all lymph nodes between the skin and the deep muscle plane from the mandible to the omohyoid muscle

Technic of Removal of Suprahyoid Lymph-Nodes The following technic is employed by Fischel (38) (fig 712) The patient is anesthetized the table is tilted upward 45

degrees, and the head is hyperextended The operative field is prepared and draped. (1) A transverse incision is made across the neck at the level of the hyoid bone, extending from one mastoid process to the other The upper flap is undercut in a plane superficial to the platysma muscle, so that it will comprise only the full thickness of the skin, and is raised to the level of the upper border of the mandible The vessels in the superficial fascia are clamped and ligated (2) The patient's head is turned to the left, and the line of the initial incision is deepened through the platysma and fascia to expose the deep cervical fascia and the anterior border of the right sternocleidomastoid muscle The large veins here encountered are clamped and ligated to prevent an undue loss of blood The incision is now carried slightly upward along the sternocleidomastoid muscle, and then directed forward in search of the facial vein, which, when identified, is doubly clamped, cut, and ligated at both ends The deep fascia is then raised from the anterior belly of the digastric and right mylohyoid muscle An identifying clamp is placed on the deep fascia at the point where it divides to form the capsule of the submaxillary gland (3) Beginning at the upper and outer limits of the incision, the facial artery and vein are clamped, cut, and ligated The fascia is raised from the lower portion of the masseter muscle, exposing the periosteum of the mandible from the angle to the midline (4) With the tissues loosened in this manner, the submaxillary gland is elevated and pulled forward by the exertion of traction on the identifying forceps previously placed in the cut edge of the deep fascia The facial artery is ligated close to its entrance into the gland The dissection of the right side is completed from the parotid tissue toward the midline, but no attempt is made at this stage to clean out the submental triangle (5) The operative team now changes sides The patient's head is turned to the right, and the dissection on the left side is carried out in a similar manner The final step in the removal of the tissues is the dissection of the submental triangle This is carried out after the tissues are raised toward the midline With the assistant exerting traction on the loosened tissue, the space between the anterior bellies of the digastric is cleared Finally, the last attachment at the symphysis is severed

Following the neck dissection the wound is loosely closed with interrupted sutures Gauze packs are placed in the large spaces left by the removal of the submaxillary salivary glands, and rubber drains are sewn into the lateral angles of the wound for the purpose of carrying off saliva from the cut surfaces of the parotid glands

The chief risks of the operation are damage to the hypoglossal nerve in its course across the submaxillary space on the surface of the hyoglossus muscle, injury to the lingual branch of the fifth nerve situated high in the submaxillary triangle, and the unavoidable sacrifice of the cervical branch of the seventh nerve which results in a drooping of the angle of the mouth Fischel (39) points out, however, that since both sides are affected, the deformity and interference with function is negligible

(2) **Palpable Cervical Nodes.** In cancerous growths accompanied by palpable fixed or movable submental and submaxillary nodes which have not broken through their capsules there is little difference of opinion as to the proper management It is generally agreed that even if the prognosis be poor, complete excision of the initial tumor, together with a block dissection of the lymphatic vessels and nodes from the mandible to the clavicle (15, 96) on one or both sides, depending upon the location of the original lesion, is indicated Should dissection be required on both sides of the neck, the operation is performed in two stages

Irradiation in such instances would scarcely be indicated, since, as has been previ-

ously stated, a dose sufficient to destroy the cancer cell within the node would necessarily cause such wide destruction of the superficial tissues as to require a plastic reconstruction as extensive as though the nodes had been removed surgically in the first place. In cases showing enlargement of but one or two isolated nodes, however, radium element or radon seeds can be implanted interstitially in a dosage powerful enough to destroy the cancer cell without injury to the surrounding tissues In such cases Martin (63) proceeds as follows The outer surface of the node is exposed surgically Its diameter is measured by calipers and in those measuring up to 2.5 cm. a

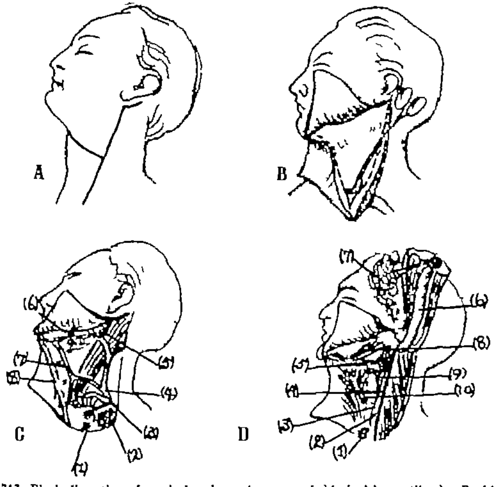


Fig 713 Block dissection of cervical nodes. *A* course of skin incision outlined. *B* skin flap reflected Deep fascia incised, as indicated by dotted line, and its dissection begun. *C* sternocleidomastoid muscle divided, internal jugular vein ligated and cut. *1* internal jugular divided. *2*, supraclavicular fat, *3*, clavicular end of sternocleidomastoid muscle *4* external jugular vein *5* parotid gland *6* facial vessels ligated and divided *7* anterior jugular vein *8* incision made in deep fascia. *d* posterior belly of omohyoid, internal jugular vein fat and fascia raised. *1* internal jugular vein ligated and divided, *2* vagus nerve *3* common carotid artery *4*, descendens hypoglossi nerve *5* hypoglossal nerve, *6* internal jugular vein *7* fat *8*, digastric muscle *9* superior thyroid artery *10* anterior belly of omohyoid. For details, see text. (Spencer-Cade)

quantity of gold radon seeds sufficient to deliver 7 to 10 skin erythema doses is implanted. In larger nodes, 3 to 6 cm. across the treatment is carried out "by the use of the divided dose or protracted dose principle over a period of three to four weeks, giving up to 4500 or 5000 roentgens or even more depending on the size of the portal which should be kept rather small (5–7 cm) Immediately on the completion of this series, radon gold seeds are implanted into the residual node the dose (usually not more than 6–7 S.E.D) depending on its size.

Technic of Complete Removal of Cervical Nodes (fig 713) After the usual aseptic

preparation, anesthesia, and draping, the neck is hyperextended by means of a sandbag placed beneath it Various types of incisions are employed for the purpose, an excellent approach being obtainable through one extending from the mastoid process to the sternoclavicular joint and joined by a second incision carried from the symphysis to a point just above the middle of the sternomastoid muscle The skin, superficial fascia, and platysma are divided, and the tissues in the flap thus outlined are turned back, the cervical fascia of the anterior triangle being thus widely exposed The sternomastoid is defined along its anterior border and reflected backward The cervical fascia and the underlying cellular tissue, together with the lymphatic nodes, are dissected upward in the form of a flap, exposing the great vessels and their sheaths The nodes in relationship to the internal jugular vein are peeled upward Tributaries of the vein will require ligation and cutting to permit of their mobilization. The infrahyoid group of muscles is cleared and all loose fatty tissue removed During the dissection the external jugular vein and the great auricular nerve should be preserved whenever possible When the upper region of the neck is reached, the submaxillary triangle is cleared and the submaxillary gland removed, together with the neighboring lymph-nodes The dissection is then carried forward to the submental region, and the lymph-nodes between the geniohyoid muscles are resected Two or three nodes will be found above the hyoid, between the bellies of the digastric The spinal accessory nerve lying in the upper and posterior part of the field is identified at the point where it enters the deep surface of the sternomastoid muscle The lower portion of the parotid gland is exposed and may require excision to allow resection of the parotid group of lymph-nodes Occasionally, the nodes are so adherent to the internal jugular vein that they can be removed only after ligation and excision of the vein itself Blunt dissection is employed in the clearing out of the structures low down in the neck It is impossible to remove the glandular areas without resection of the greater part of the sternomastoid muscle The lymphatic tissue is stripped from the clavicle below to the floor of the mouth and base of the skull above At the completion of the operation, and prior to the closure of the wound, radium emanation tubes are buried at certain of the more dangerous points

If the nodal involvement is bilateral, the opposite side of the neck is subjected to similar surgery after an interval of 10 days In case the internal jugular vein on one side has been sacrificed, great care must be taken to preserve the one on the other side

(3) **Inoperable Cervical Nodes.** In cases wherein the metastases are widespread, the nodes have ruptured through their capsules, the general state of the patient is poor, or the primary lesion is uncontrollable, the condition is considered hopeless Under such circumstances surgical removal does not guarantee a sufficient percentage of cures to justify operative intervention, and here external irradiation, reinforced by interstitial implantation, will relieve pain, retard the progress of the lesion for a long period, and offer hope of an occasional cure Patients who are physically able are subjected to external irradiation equivalent to 2 or 3 skin erythema doses applied to each side of the neck over a period of 2 or 3 weeks This is supplemented by interstitial irradiation, the tubes being introduced directly through the anesthetized skin and distributed uniformly throughout the mass Swinton and Trommald (88) employ "roentgen ray of 200 K V filtered through 1 mm of copper The doses are fractionated to deliver at least 2400 roentgen units to each skin area, usually using one

skin portal on each side of the neck, each portal not to exceed 80 sq cm. in size The treatment is extended over a period of 14–18 days.'

Prognosis

Early lip cancer without evidence of metastases, if properly treated, should give from *90 to 100 per cent cures (16, 85) If one gland is involved when treatment* is begun, cures average 70 per cent, with two or more glands affected, the figures drop to 40 per cent (76)

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CHAPTER XVI

CLEFT LIP AND CLEFT PALATE

ANATOMIC CONSIDERATIONS

While it is not within the scope of these pages to enter into a detailed discussion of the anatomy and physiology of the parts involved, nevertheless a short résumé of certain pertinent facts is essential to a comprehensive understanding of the operative problem.

For the description of the anatomy of the lip the reader is referred to page 1064

The palate is a flattened vault forming the roof of the mouth. The anterior part, or *hard palate*, separates the oral from the nasal cavity and is composed of the palatal processes of the maxillae and the horizontal plates of the palatal bones It is bordered in front and laterally by the alveolar processes which end posteriorly in the maxillary tuberosities. Behind and slightly medial to these tuberosities the hamular processes can be felt. The posterior margin of the bony palate gives attachment to the soft palate. At the posterolateral angles on a level with, and close to, the last molar tooth on either side is the posterior palatine foramen. This opening transmits the great posterior palatine nerve and the great palatine artery which courses forward on the oral surface of the hard palate close to the alveolar border, nearer to the bone than to the mucous membrane and passes into the nose through the incisive foramen. This artery is the main source of nutrition for the palate Therefore, in the raising of mucoperiosteal flaps the incision must be made close to the alveolus, lest the vessel be damaged (fig 715) Both the oral and nasal surfaces of the hard palate are covered with a smooth, tough mucous membrane which fuses with the periosteum so intimately that the two structures cannot be separated. As will be seen later, the toughness of the membrane is of great advantage in the formation of flaps for the closure of palatal clefts. The mucosa on the oral surface is continuous anteriorly and laterally with that of the gums and posteriorly with that of the soft palate It is thin in the center and becomes thicker toward the periphery It is most firmly attached to the bone along the median raphé and at the alveolar borders. Beneath the mucous layer is a compact mass of racemose glands resembling the salivary glands. The ducts opening on the surface, give the mucous membrane a pitted appearance.

The *soft palate* (velum palatinum) is a musculomembranous fold extending backward from the hard palate into the pharynx Its function is to serve as a valve to close off the nasal cavity during speech and deglutition. The upper surface of the velum is convex and covered with mucous membrane continuous with that of the nasal cavity, its under surface is concave and lined with mucous membrane merging with the oral mucosa. Anteriorly the velum is attached to the hard palate by means of the palatal aponeurosis and mucous membrane its posterior margin is free and gives off the uvula in its central portion laterally it is attached to the sides of the pharynx and

tongue by means of two muscular folds One fold (palatoglossus) is directed outward, downward, and forward to the side of the tongue and forms the anterior pillar of the fauces, the other (palatopharyngeus) passes outward, downward, and backward to the side of the pharynx to form the posterior pillar The aperture between the anterior pillars constitutes the isthmus of the fauces through which the mouth communicates with the pharynx

From the pharyngeal to the oral surface the soft palate presents the following structures, each of which has special surgical significance (fig 714). (1) *Pharyngeal mucosa*, which is unevenly red and resembles the nasal mucosa (2) *Upper layer of the palatopharyngeus muscle* This muscle is situated in the posterolateral part of the soft palate and with its mucous covering forms the posterior pillar of the fauces It takes origin in the soft palate, extends downward, outward, and backward, embracing the levator palati and musculi uvulae, and is inserted into the thyroid cartilage and into the lower

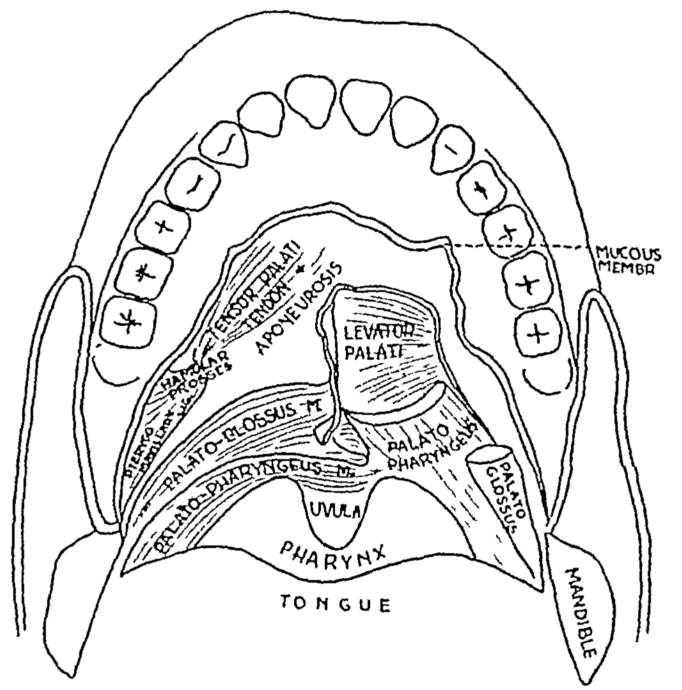


FIG 714 Arrangement of muscles in soft palate

part of the pharynx near the midline Its action is to depress the palate, elevate the larynx and tongue, and approximate the pillars of the fauces, thus shutting off the oropharynx from the nasopharynx Its nerve supply is derived from the pharyngeal plexus (3) *Musculi uvulae*, two muscles situated in the soft palate close to the midline They originate in the posterior nasal spine and palatal aponeurosis and pass downward to join below in a free extremity Their function is to shorten and elevate the uvula They are probably supplied by the spinal accessory nerve through the pharyngeal plexus (4) *Levator palati muscle*, situated in the upper portion of the palate behind the tensor palati This muscle takes origin in the petrous portion of the temporal bone in front of the carotid canal, and passes downward, inward, and forward, to be inserted into the palatal aponeurosis Its purpose is to elevate the palate and bring it in contact with the posterior pharyngeal wall Its nerve supply is probably derived from the spinal accessory through the pharyngeal plexus (5) *Lower layer of the palatopharyngeus muscle.* (6) *Tensor palati muscle* (*tensor veli*

palatini) and *palatine aponeurosis* The tensor palati arises from the internal pterygoid plate, spine of the sphenoid, and eustachian tube passes down to the hamulus, turns at a right angle over the hamular process which serves as a pulley, and is inserted into the central part of the under surface of the palate The muscle lies lateral to the eustachian tube and pharyngeal aponeurosis and medial to the internal pterygoid muscle and mandibular division of the trigeminal nerve Its function is to raise the palate to the level of the hamular process counterbalance the action of the levator, and aid in the dilatation of the eustachian tube. Its nerve supply is derived from the third division of the trigeminal. (7) *Palatoglossus muscle* This muscle is situated on the

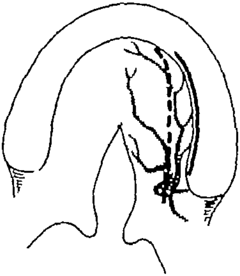


FIG. 715 Course of great palatine artery Solid line indicates correct location for incision Incision along dotted line would destroy main blood supply of flap. (Wardrasse)

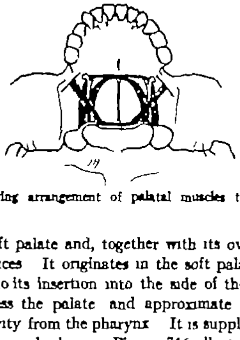


FIG. 716. Diagram, showing arrangement of palatal muscles to form pharyngeal sphincter (Browne)

side and front of the soft palate and, together with its overlying mucosa forms the anterior pillar of the fauces It originates in the soft palate and passes downward, outward, and forward to its insertion into the side of the tongue Its action is to elevate the tongue depress the palate and approximate the anterior pillars, thus shutting off the oral cavity from the pharynx It is supplied by the eleventh cranial nerve through the pharyngeal plexus. Figure 716 illustrates diagrammatically the arrangement of the palatal muscles in the formation of the pharyngeal sphincter (8) A thick layer of *mucous glands* (9) *Oral mucosa*, which is smooth rosy red, and continuous posteriorly with the pharyngeal mucosa.

The soft palate receives its blood supply from the descending palatine branch of the internal maxillary artery, the ascending pharyngeal artery, and the ascending palatine branch of the external maxillary artery. The two last-mentioned vessels follow the course of the levator palati muscle and are injured when the hamular process is sectioned

The function of the soft palate is to regulate the communication between the nasopharynx and oropharynx for the purpose of speech and deglutition Thus, during the act of swallowing, the palate is lifted upward and backward, in sucking it is drawn downward and forward, and in articulation it assumes every attitude between these extremes The majority of phonetic sounds depend for their proper enunciation upon

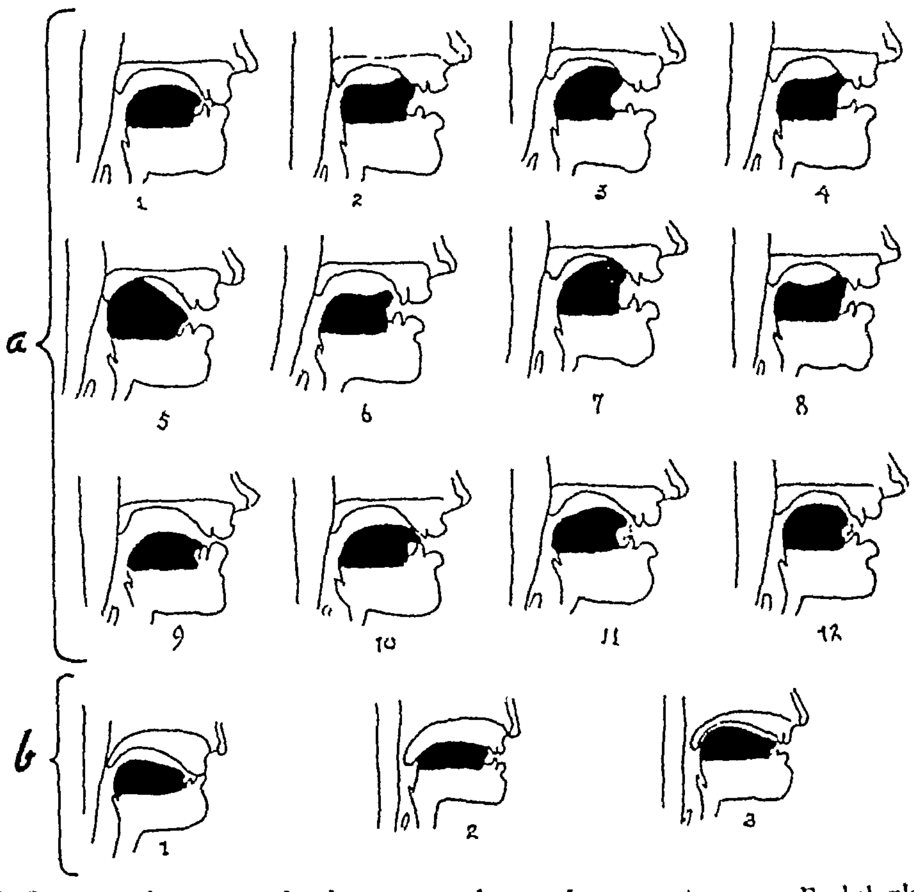


FIG 717 Position of tongue and palate in articulation of consonants *a*, in English plosives and fricatives *1*, p, b, *2*, t, d, *3*, clear l, *4*, dark l, *5*, k, g, *6*, r, *7*, ch, *8*, tr, *9*, f, v, *10*, th, *11*, s, z, *12*, sh, r *b*, in nasal consonants *1*, m, *2*, n, *3*, ng (Nena Kate Ramsey)

a complete shutting off of the nasopharynx from the oropharynx (fig 717-a), the only sounds requiring an open position of the velum being m, n, and ng (fig 717-b). It follows then that in cases of cleft palate, wherein the pharyngeal valve is unable to occlude the aperture, speech is greatly impeded

The closing off of the nasopharynx from the oropharynx is accomplished by the joint action of three factors (1) The superior pharyngeal constrictor muscle contracts, producing an elevation on the posterior wall of the pharynx, called Passavant's pad (figs 718–719) This ridge narrows the pharynx anteroposteriorly (2) At the same time the levators of the palate contract and swing the velum upward and backward to approximate the ridge on the posterior wall (3) The closure is completed by the contraction of the palatopharyngeus muscle which moves the lateral pharyngeal walls

medially, thus narrowing the opening from side to side. Failure of any one of these elements to do its share will interfere with function. For example, in a cleft of the soft palate the independent pull exerted by the muscles on each half of the divided palate tends to bring the parts forward and outward, thus increasing rather than decreasing the diameters of the aperture and rendering impossible the closing off of the nasopharynx during speech. Accordingly, the shunting of the air from the mouth into the nose causes the voice to assume a nasal quality D sounds like N, and B like K, and the patient is unable to enunciate K and G The interference with vowel phonation is so marked that these sounds are scarcely intelligible The patient, in an

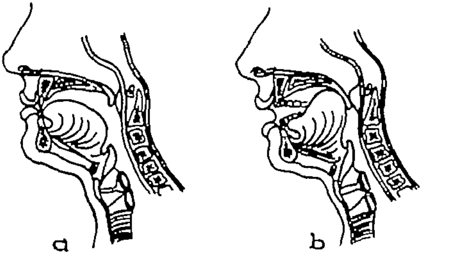


FIG. 718. Diagram, showing mechanism of shutting off of nasopharynx from oropharynx by *a*, contact of velum with Passavant's pad *b* contact of palate, posterior pharyngeal wall, and tongue. (Browne)

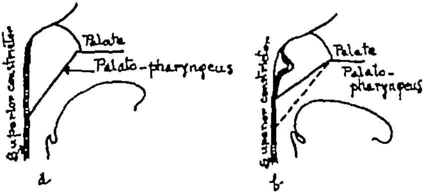


FIG. 719 Formation of Passavant's pad. *a*, posterior sling relaxed. Constrictor muscle flat against vertebra, and palatal fringes at full length. *b* contraction of palatopharyngeus pulls up constrictor in form of cushion on posterior pharyngeal wall. (Browne)

endeavor to conceal his affliction and make speech understandable, employs muscles other than those normally used for the purpose For instance, the sounds K and G, which are customarily produced by the arching of the tongue against the soft palate (fig 717), in these cases are evoked by the application of the tip of the tongue to the posterior pharyngeal wall. In addition, the nasal muscles are requisitioned to contract the nasal orifices with a view to limiting the escape of air from these passages.

CLASSIFICATION OF CONGENITAL CLEFTS OF LIP AND PALATE

Congenital clefts of the lip and palate range in extent from a barely perceptible notching of the lip or uvula to a complete separation of all the palatal structures, the

premaxilla standing out from the nasal base in the form of a snout. Between these extremes every intermediate type of cleft is encountered The most practical classification of these anomalies is that suggested by Davis and Ritchie (21), who base their differentiation upon the condition of the alveolus

Group I. Prealveolar Clefts In this group the lip is cleft, but the alveolar process is intact, although there may be an associated cleft of the palate The deformity is either unilateral or bilateral, and the separation may be incomplete—in which case the summit of the cleft ends in the labial substance, or complete—wherein the division extends into the floor of the nose

Group II Postalveolar Clefts Here the palate is cleft, but the alveolar process is intact, although there may be an associated prealveolar cleft. The deformity may be limited to a part of the palate, or may extend from the uvula behind to the anterior palatine foramen in front

Group III Alveolar Clefts In this group the alveolus is incompletely or completely cleft on one or both sides There is usually an associated prealveolar and postalveolar cleft. In the complete unilateral type the division passes between the pre-

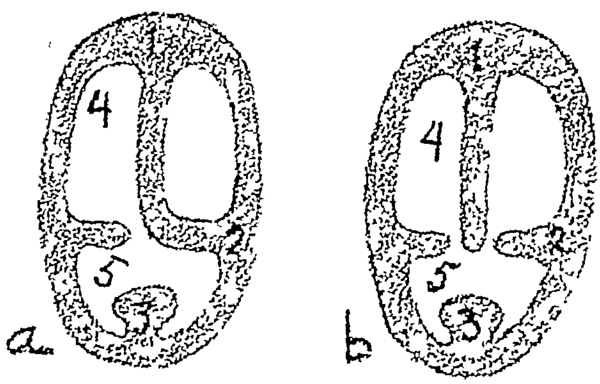


FIG 720 Diagram, illustrating types of cleft palate *1*, ethmovomerine septum *2*, palatal segments *3*, tongue *4*, nasal cavity *5*, buccal cavity *a*, shows ethmovomerine septum united to only one palatal segment, causing mouth to communicate with one nasal fossa *b*, shows failure of ethmovomerine septum to coalesce with both palatine segments, causing mouth to communicate with both nasal fossae

maxilla and the maxilla on one side, and the nasal septum is attached to the palatal process of the opposite side Thus one nasal fossa communicates with the oral cavity (fig 720-a) In the complete bilateral variety the premaxilla is entirely separated from the alveolar process on both sides and is displaced forward and upward in front of the alveolar arch The cleft takes the form of a Y, the oblique limbs being directed anteriorly, embracing the premaxilla, and the single limb extending posteriorly between the halves of the palate The nasal septum is unattached and hangs free in the midline, both nasal fossae communicating with the mouth (fig 720-b).

The type of cleft most commonly encountered is a unilateral cleft alveolus with an associated cleft lip and cleft palate, this combination comprising about 48 per cent of all cases Next in frequency is the simple unilateral cleft lip, which includes approximately 33 per cent Bilateral cleft alveolus with involvement of the lip and palate occurs in 12 per cent, and simple bilateral cleft lip in only 7 per cent of cases. Median clefts of the lip and alveolus are surgical curiosities and are usually associated with other malformations, such as absence of the philtrum, columella, or septum, or with a median cleft of the nose (87)

ETIOLOGY

Since mention of congenital clefts is omitted from official birth records, no accurate information as to their incidence is obtainable. Perron (68) in France found one such deformity in 942 births. Davis (19) in America, in a review of 28,085 consecutive deliveries found one such case in 915 births in the white race and one in 1,788 in colored races. The anomaly is twice as frequent on the left side as on the right and is more common in the male than in the female in the proportion of 3 to 1 Haug (44), in a review of 2,352 cases collected from the literature, found 64.3 per cent males and 35 7 per cent females. In Davis statistics 70 per cent were males.

A hereditary predisposition seems to be a factor in the production of these deformities (3, 34 58) Schroeder (80) found at the Surgical Clinic in Muenster between 1932 and 1934 that heredity was responsible in 42 7 per cent of the cases. He believes that the condition becomes exaggerated from generation to generation, so that a unilateral cleft in a parent may be transmitted as a bilateral cleft in the offspring The age and mentality of the parent, consanguinity, pathologic changes in the reproductive organs, and syphilis do not appear to play a part Malnutrition and infection have been suggested as contributing causes, inasmuch as the anomaly is more common among the poor

The direct cause is unknown Many hypotheses, all conjectural, have been set forth, but no explanation is applicable to all cases. Prenatal maternal impressions and psychic trauma have been advanced but with no material basis. Mechanical factors that prevent approximation of the embryonic segments have been suggested, such as intervening mucosa during dental evolution (12), amniotic bands, intra uterine adhesions, hypertrophy of the pharyngeal tonsils, and failure of the tongue to descend from between the palatal processes (84) Schaeffer (78) states "Indeed, one wonders whether too long a sojourn of the tongue between the palatine processes is not a cause of some of the clefts encountered later in the secondary portion of the hard palate." Cryer (17) ventures the opinion that the mandible which develops before the maxilla, may possibly interfere with union of the maxillary elements when the fetal head is hyper flexed. Warnekros (91) believes that the presence of supernumerary teeth may play a part In recent years, however the development of x ray has largely discredited the mechanical theories.

PATHOGENESIS

In embryonic life the buccal and nasal cavities form one continuous chamber As growth proceeds, the oral aperture becomes walled off from the nasal by the palate, and the nasal fossae are separated from each other by the nasal septum This change is brought about in the following manner (fig 721) About the second week of intra uterine life the primitive mouth and nasal cavity is bordered by five mesenchymal primordia—the frontonasal process above, the two maxillary processes at the sides, and the two mandibular processes below Faulty or interrupted fusion of any of these elements explains clinically all congenital facial clefts During the course of development the frontonasal process divides into a medial and two lateral nasal processes which grow downward and merge with each other and with the maxillary processes. On the medial process arise two small masses called the globular processes. These unite to

become the central third of the upper lip, the philtrum, the premaxilla, and the nasal septum Non-fusion of these processes is responsible for a median cleft lip The lateral nasal processes form the walls of the nose and coalesce with the maxillary processes to form the cheek, but they take no part in the formation of the lip The maxillary processes grow medialward but are prevented from meeting in the midline by the interposition of the frontonasal segment They form the outer thirds of the upper lip and the greater part of the cheeks, palate, and maxillae Non-union between one or both maxillary processes and the frontonasal process results in a unilateral or a bilateral cleft lip The mandibular processes fuse with each other in the median line to form the mandible, lower lip, and chin Failure of these processes to fuse gives rise to a median cleft of the lower lip, a rare anomaly, underdevelopment leads to micrognathia. Deficient union between the mandibular and maxillary processes results in macrostomia, and excessive fusion in microstomia

Embryologically, three segments combine to form the *bony palate*, fusion taking place from before backward and being complete by the ninth week The anterior or premaxillary part (os incisivum), carrying the incisor teeth, develops from the fronto-

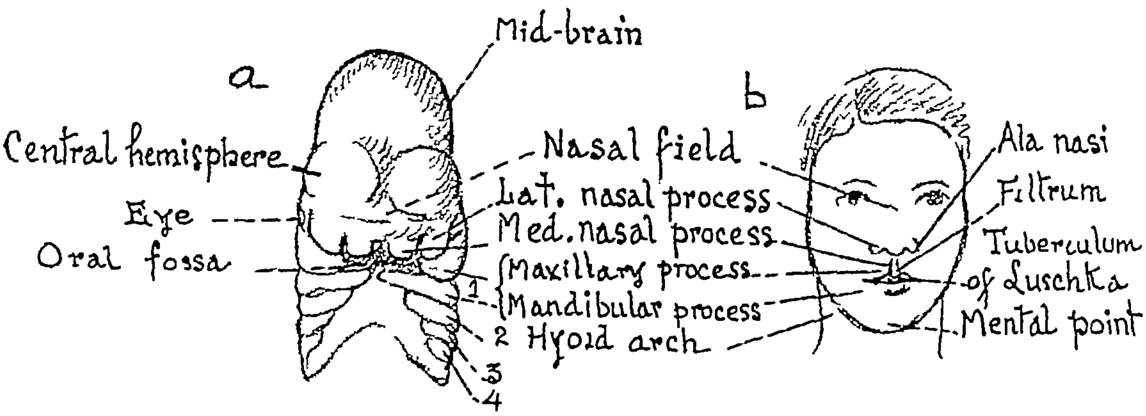


FIG 721 Derivatives of definitive portions of face from embryonic primordia (Jordan and Kindred)

nasal process, the two lateral portions, bearing the deciduous canines and molars, are derived from the right and left maxillary processes In the posterior two-thirds of the palate the maxillary processes merge with each other in the median line, but in the anterior third they unite with the premaxilla Thus a Y-shaped line of fusion is formed, the union of the maxillary processes with each other representing the vertical limb, and the coalescence of the premaxillary and maxillary processes corresponding to the oblique limbs Accordingly, all clefts which form behind the anterior palatine foramen will lie in the median line, and those in front of it will be placed laterally Failure of all three elements to fuse will result in a Y-shaped cleft, double anteriorly and single posteriorly (fig 722) The number of teeth in the premaxilla varies, since the germs of the lateral incisors may develop on either side of the cleft or may be lost in it In the majority of cases the lateral incisors are missing, the separation lying between the central incisor and canine.

Coincident with the fusion of the structures which serve to form the palate there is a downward growth of the nasal septum and a fusion of this partition in the midline with the palatal processes of the maxillae If the coalescence of the latter processes is arrested, the nasal septum will also be prevented from uniting with one or both of them,

and the oral cavity will be left to communicate with one or both nasal fossae. Thus, should the septum unite with only one palatal process, the mouth will communicate with one nasal cavity, should it fail to merge with both processes, it will project free in the cleft, and the oral cavity will open into both nasal fossae (fig 720)

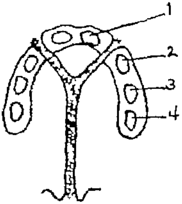


FIG. 722. Embryologic segments of bony palate. Premaxillary portion carrying incisor teeth 1, developed from frontonasal process. Two lateral portions, bearing canine and molars 2-3-4 derived from maxillary processes. In posterior ⅔ of palate maxillary processes merge with each other but in anterior ⅓ they unite with premaxilla, forming Y-shaped line of fusion Thus, anterior clefts will be situated laterally and posterior clefts in midline.

GENERAL OPERATIVE CONSIDERATIONS

Preparation for Operation

In these anomalies immediate operation is as a rule not imperative, as the condition in itself is not a cause of inanition. While it is true that feeding is more difficult than in the case of normal infants, nevertheless with patience the child can be amply nourished. In view of the elective character of the surgical procedure an opportunity is afforded of placing the infant in the best possible physical condition preoperatively The services of an experienced pediatrician should be enlisted for the regulation of the diet, improvement of sleeping habits correction of digestive disorders, and for the determination of the optimal time for surgical intervention Under no circumstances should one allow oneself to be persuaded by the importunities of the parents to operate on a poorly nourished dehydrated infant with a deranged gastro-intestinal tract, or one who is steadily losing in weight or suffering from a local or general infection The healthy infant requires little preparation, aside from dietary control If he is unable to suckle he is taught to receive nourishment by means of some artificial feeder, such as a medicine dropper or a special feeding bottle equipped with a broad obturator Whenever possible, the child should be breast fed otherwise a suitable formula must be worked out preoperatively Regular feedings are given up to within 3 hours and water up to 2 hours, of the time of operation.

Older children should be admitted to the hospital several days before operation, so that they may become accustomed to their new surroundings. Palatal operations are best performed during the spring and summer months. As a precaution against infection diseased tonsils and adenoids should be removed carious teeth attended to, and healthy teeth scaled and polished 3 to 4 weeks before operation to allow ample time for the healing of all wounds. The advisability of removing enlarged pharyngeal

or faucial tonsils is a debated question Some believe that they should be retained, on the grounds that they assist in closing off the opening

Before operation the following routine procedures are carried out laboratory examinations, including cultures of the secretions of the nose, throat, ear, and vagina, blood count, estimation of hemoglobin content and coagulation and bleeding time, urinalysis, and Wassermann test Some surgeons stress the importance of an enlarged thymus gland and make routine x-ray examinations to ascertain its presence (p 453) Investigations are also conducted to show exposure to contagious diseases and a familial tendency to hemophilia In all cases the infant is blood-grouped and a suitable donor held in readiness For statistical purposes photographs are made and accounts kept of the history, operation, and progress of the condition

In cleft lip and palate operations the child is wrapped mummy-fashion in a wool blanket and sheet The face is swabbed first with ether and then with alcohol While the position of the patient varies with the surgeon's individual preference, it is usually found most convenient to place the child on his back, with the head hanging over the end of the table (Rose's position) and resting on a pillow on the operator's knees The table pad is extended somewhat beyond the table as a protection for the neck While this position predisposes to hemorrhage by the venous congestion it induces, this objection is outweighed by the guarantee it affords against the aspiration of blood After anesthesia, a traction suture is drawn through the tip of the tongue to prevent its falling back into the pharynx during recovery The assistant stands to the surgeon's right throughout the operative procedure and with a suction apparatus keeps the field clear of blood

Anesthesia

The operation may be performed either under general or local anesthesia (1) If a general anesthetic is used, ether warmed and vaporized is administered through a nasal tube introduced into the unaffected nostril, only enough of the agent being given to allay sensibility Profound anesthesia is to be avoided, as the loss of the pharyngeal reflex incurs the danger of aspiration of blood In the case of older children, avertin is employed, supplemented by gas-oxygen introduced by the endotracheal method (p 433) In either case it is advisable to inject along the margins of the cleft a few drops of a 0 5 per cent procain epinephrin solution This not only minimizes hemorrhage, but also facilitates the dissection

Postoperative Care

After the operation the child is kept in the operating room until he has fully recovered consciousness and the surgeon has satisfied himself that the airway is clear, hemorrhage has been controlled, and there is no evidence of shock If the general condition is doubtful, small blood transfusions or saline infusions are administered and oxygen inhalations given When his condition is deemed satisfactory, he is placed in a warmed bed, and restraining cuffs are applied around the elbows to limit the movements of the arms The position he is made to assume will depend upon the character of the operation Following lip repair he is laid on his back and after palatal operations, on his abdomen He is then entrusted to the care of a nurse experienced in the handling of this class of surgical patients

Food is offered as soon as the infant regains consciousness and is thereafter given at 3- to 4-hour intervals. Suckling children receive expressed mother's milk for the first day and are put to the breast on the second. Sterile water is administered every 2 or 3 hours. The diet of older children is limited to milk and fruit juices for the first 4 days, after which time they are placed on a soft diet of custards, jellies, puddings, etc., for 10 days. After each feeding the mouth is sprayed with normal salt or boric acid solution. Should this cause the child to struggle however, it should be dispensed with. In order that the intestinal tract may be cleared of swallowed blood, a dose of castor oil is administered soon after operation The nostrils are kept clean and anointed frequently with boric acid ointment. During the early postoperative period every effort should be made to induce quiet and thus prevent tearing out of the stitches To effect this, phenobarbital 0 03 gram is administered as soon as consciousness is regained, and 0 008 gram is given every 4 hours thereafter for the first 48 hours. Weather permitting, the child is taken out of doors on the second or third postoperative day

A postoperative rise of temperature to 101 or 102 degrees within the first 24 hours is to be expected, but this fever usually subsides in 48 hours. The general complications most frequently observed are bronchitis, pneumonia and vomiting due to acidosis. Locally, the sutures may cut out as a result of tension or infection, or the child may tear them out with his hands if the latter are not properly secured. Finally, sloughing of the palatal flaps may take place from interference with circulation or from infection Should such accidents occur, an interval of 3 to 6 months should be allowed to elapse before secondary repair is undertaken

The patient should be seen by the surgeon every few months for a year or two following the operation, so that any secondary deformities, such as inequalities in the level of the lip and flattening of the nostrils, may be corrected. Following palatal operations, the child is placed under the care of an orthodontist as soon as the teeth erupt, so that steps may be taken for the prevention or correction of irregularities of the teeth and for the expansion of the maxillary arch. He is likewise assigned to a specialist in speech training for education in the proper use of the newly constructed palate

With proper management the operative mortality should be negligible The surgical deaths which do occur can be traced largely to faulty control of hemorrhage and to injudicious selection of patients, in whom death would probably have resulted even without operation.

PREALVEOLAR CLEFTS

In the repair of prealveolar clefts the chief consideration is improvement in appearance and if the results of the operation are to be satisfactory, the deformity must be carefully studied beforehand.

Unilateral clefts, as has been said before, range from a mere dimpling of the vermilion border to a complete cleft extending into the nasal vestibule. In the more extensive types, on the *medial side* of the cleft the deep surface of the lip is firmly attached to the bone, the frenum being frequently absent. Due to the unopposed action of the split muscle, the lip is pulled toward the unaffected side, exposing the alveolar process. The margin of the cleft is thin owing to the poor development of the muscle. The lower portion of the philtrum is often missing The vermilion border, however, is as a rule well marked and may reach to the inner margin of the nostril. The tissues on

the *lateral side* of the cleft, on the other hand, are thick, contain well-developed muscle, and completely cover the alveolar process

Every type of cleft lip, even that in which the cleft is a mere notch, is invariably accompanied by some degree of nasal deformity, the extent depending upon the amount of lip involvement When the cleft is incomplete and narrow, both nostrils may appear well formed and fairly symmetrical But when it is complete and the parts widely separated, the long axis of the nose as a whole is deviated, the ala on the affected side is stretched over the bony cleft, often being flush with the cheek, the nostril appearing as a transverse slit, the alar base lies at a lower level than that on the normal side and farther from the median plane, so that a vertical line drawn through the alar-facial attachment would lie outside the angle of the mouth, the columella is tilted obliquely, and the distance from its base to the tip of the nose on the affected side is less than that on the unaffected side, the septum is deflected and buckled, so that its lower border,

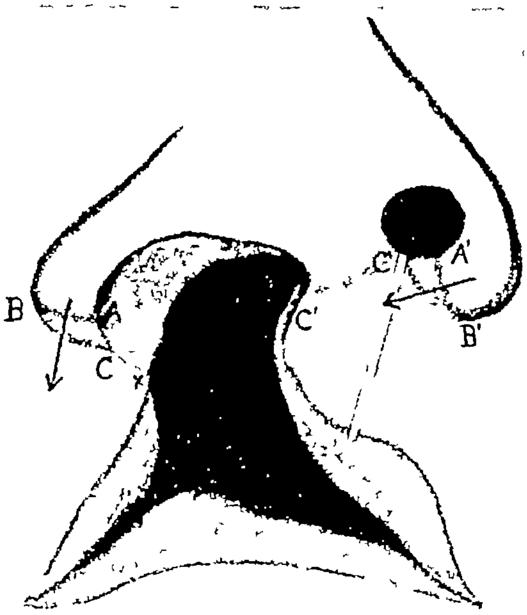


FIG 723 Unilateral cleft lip Arrows indicate direction in which alae nasi point Curved line *XCAC'*, line of demarcation between skin and nasal mucous membrane White line, measurement for determination of depth of future lip Shaded area between *C* and *C'*, boundary between philtrum and columella (Thompson, Trans Am Surg Assoc, Vol 44)

instead of being hidden in the midplane of the columella, lies exposed across the nostril of the normal side, and the lower lateral cartilage on the side of the defect is distorted and separated from its fellow, giving the tip of the nose on that side a flattened appearance with a depression at its summit (fig 723) In bilateral clefts the disfigurement is often less apparent, since the malposed structures are symmetrically placed

Early surgeons contented themselves with a mere closure of the defect, giving little concern to the esthetic and physiologic results or to future developmental changes No attempt was made to unite the split orbicularis oris muscle or to rebuild the structures entering into the formation of the floor of the nose In the approximation of the margins of the cleft the skin and mucous membrane were sacrificed (25), and the parts were united under tension with through-and-through sutures As a result, the repaired lip was too tight from side to side, often presenting a broad flattened scar, the vermilion border was drawn up at the suture line, and the appearance of the malpositioned nose

base remained unaltered As experience in this type of surgery broadened, many of these unsatisfactory consequences, both cosmetic and functional, were overcome, and today the method of repair has been improved to such a degree that with ordinary care the lip can be restored to approximately its normal appearance with little or no disturbance of function although the reconstruction of the nose still leaves much to be desired.

Optimal Time for Operation

Some surgeons operate on prealveolar clefts within the first 48 hours of life (4), on the grounds that the infant thrives better following early closure of the cleft, the ultimate cosmetic results are more satisfactory, and the anxiety of the parents is immediately assuaged. Others postpone the procedure for from 2 weeks to 3 months after birth, in the belief that delayed surgery lessens the technical difficulties, as the lip, being then larger and thicker, can be more easily manipulated, the temporary cessation of feeding following operation is less hazardous and the infant is better able to survive the operative trauma.

The factor to be considered in the choice of the proper time for operation is one of health rather than one of age. Thus, no child should be subjected to surgery until he has become accustomed to taking food and is showing a gain in weight The most favorable age seems to be between 6 weeks and 2 months

Instruments

The instruments vary with the preference of the surgeon The following, however will serve to meet all needs (fig 724) Knives of the cataract type, sharp enough to cut a suspended hair, forceps—plain, dissecting, straight, and curved, Veau's twin needles, mounted on a flat disk with the points 2 mm apart, hemostats—straight and curved Reverdin's needles—straight and curved, small dural hooks, fine ophthalmic silk, mounted on atraumatic needles, horsehair, mounted on cambric needles, Veau's bronze wire, lip clamps, suction apparatus binocular loupe, head lamp, calipers with sharp points.

Technic

Modern operative technic aims at the reconstruction of the cleft lip by a readjustment of the elements involved without the sacrifice or addition of tissue, on the assumption that the parts are not underdeveloped but merely displaced as a result of faulty union (14)

In the repair of these deformities the surgeon is confronted with two problems (1) The construction of a lip physiologically efficient, and structurally of normal prominence, of sufficient height and width to amply cover the teeth, and with an uninterrupted mucocutaneous border showing no notching or excess tissue at the suture line and (2) the construction of a nose in which the tip alae, nostrils, septum, and columella are symmetrically placed in relation to the philtrum with a floor of equal thickness on both sides.

Before a description of the specific operations is entered upon, certain generalities common to all cleft lip operations will be discussed to avoid repetition Prior to the

operation all details concerning the lines of incision, undermining, and suturing should be carefully worked out, since a faultily conceived surgical procedure may result in irreparable damage to the fragile tissues The length of the two sides of the cleft are compared, calipers being used for the purpose to assure accuracy, and the lines which the incisions are to follow are marked out in a dye Cardinal points of approximation are then pricked out on the skin, since these points are difficult to identify after the parts have been separated and obscured by blood The outlines for the incisions should be arched to compensate for subsequent contraction along the suture line (46), and in cases wherein one border of the cleft is shorter than the other, the outline on

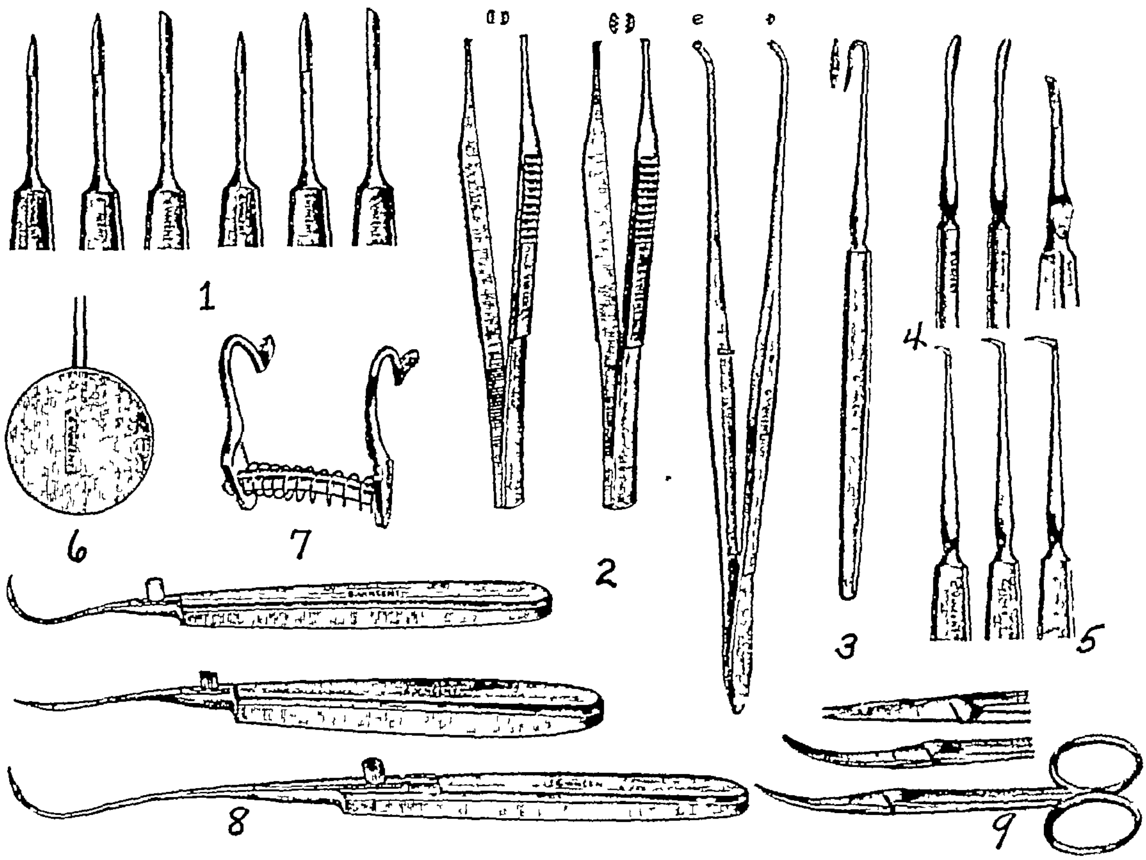


FIG 724 Instrumentarium for cleft lip and cleft palate operations *1*, variously shaped cleft palate knives, *2*, forceps, *3*, Trélat's needle, *4*, cleft palate elevators, *5*, Veau's angulated elevators 2 to 3 mm blunt, 3 to 4 mm pointed, and 7 to 8 mm pointed, *6*, Veau's twin-needles, *7*, mouth gag (Lane model), *8*, Reverdin's needles, *9*, scissors (Vincent's, Paris) Other instruments required are hemostats, straight and curved dural hooks, fine ophthalmic silk mounted on atraumatic needles, Veau's 0 1 mm bronze wire, lip clamps, suction apparatus, binocular loupe, head lamp, calipers, Lane's cleft palate needle and holder, tenacula, chisel, and mallet.

the shorter side is curved through a wider arc to equalize the surfaces to be approximated (60) For the repositioning of the nasal elements and relief of tension on the suture line, the lip and cheek are freely separated from their attachments to the maxillae through an incision along the gingivolabial groove This separation should be continued only until the sides of the cleft fall into easy approximation and the nasal elements can be rotated into their proper positions A more extensive dissection is to be avoided, as it disturbs the muscular attachments, and the subsequent cicatrization of the raw surface leads to contraction During the process of dissection the elevator should be kept close to the bone, in order that damage to the soft structures may be minimized.

Denudation of the cleft margins is carried out from above downward, the knife transfixing the full thickness of the lip, so that broad raw surfaces will remain for approximation While the tissues should be conserved as much as possible in this process, in order that the lip when sutured will not be abnormally tight and flat from side to side, in the case of incomplete clefts, however, wherein the tissues above the notch are thin, the muscle poorly developed and its fibers separated, it is best to sacrifice the atrophied tissue and convert the incomplete cleft into a complete one (fig 726) The tags of tissue turned down from the sides of the cleft are left attached below, to be used later for the construction of a prolabial tubercle. This is accomplished either by staggering the lines of incision at the vermilion border or by imbricating the ends of the mucosal flaps (16, 54, 62)

Since a relatively small loss of blood in an infant is of serious import, scrupulous consideration must be given to the control of hemorrhage. Some operators advocate the use of lip clamps applied to the corners of the mouth, but less tissue damage will result by compression of the lip between the fingers. Following the primary incision, bleeding from the superior labial artery, which is apt to be quite profuse, is checked by catching

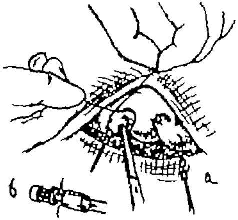


FIG 725 Control of bleeding in cleft lip operations For details see text (Douglas)

the end of the artery with a Halsted mosquito forceps and ligating it with the finest silk or catgut. Hemorrhage arising from separation of the soft parts from the bone may be stilled by pressing into the cavity a gauze tampon wrung out of hot normal saline solution Douglas (29) controls the bleeding by means of a silk suture fixed in place by a specially devised holder which also facilitates manipulation of the part. The technic is as follows (fig 725) The shoulders of the cleft lip are transfixed with a fine cambric needle carrying a silk suture. The needle is introduced from the skin side well beyond the line of incision and about midway between the outer edge of the nostril and the vermilion border The needle, with half of the silk thread attached, is then brought back *through the upper portion of the shoulder near the nostril edge*, from within outward The free end of the thread is tied to the corresponding end, so that the upper part of the lip will be compressed The other half of the thread which has already transfixed the lip is then brought around the free edge, and the two ends grasped by a specially devised clamp By an adjustment of the tension on the threads before the taps on the clamp are tightened, all bleeding is controlled without danger of cutting through the lip

Throughout the operation trauma can be minimized by manipulation of the parts

either between the gauze-covered forefinger and thumb, or with fine hooks or traction sutures Function is restored by the approximation of the separated structures in 3 individual layers—mucous membrane, muscle, and skin (73, 87). Before placing the sutures, the margins of the skin and the mucous membrane are undermined for a few millimeters to expose the orbicularis muscle The mucous membrane is sutured with horsehair. The muscle segments are united with 2 or 3 sutures of chromic catgut or aluminum bronze wire (figs 726–727) The passage of the muscle sutures can be facilitated by the use of a Reverdin needle Finally, the skin margins are approximated with on-end mattress-sutures, either fine silkworm-gut on an atraumatic needle or horsehair on a cambric needle being employed The first suture is placed exactly at the skin-vermilion junction line at the points previously marked out This stitch must be inserted with great care, lest there result an irregularity of the mucocutaneous border from the carrying of white skin into the vermilion line The next suture is introduced at the upper angle of the wound, and should be placed in such a manner as not to depress the tip of the nose when tied The mucosal tags which were turned down

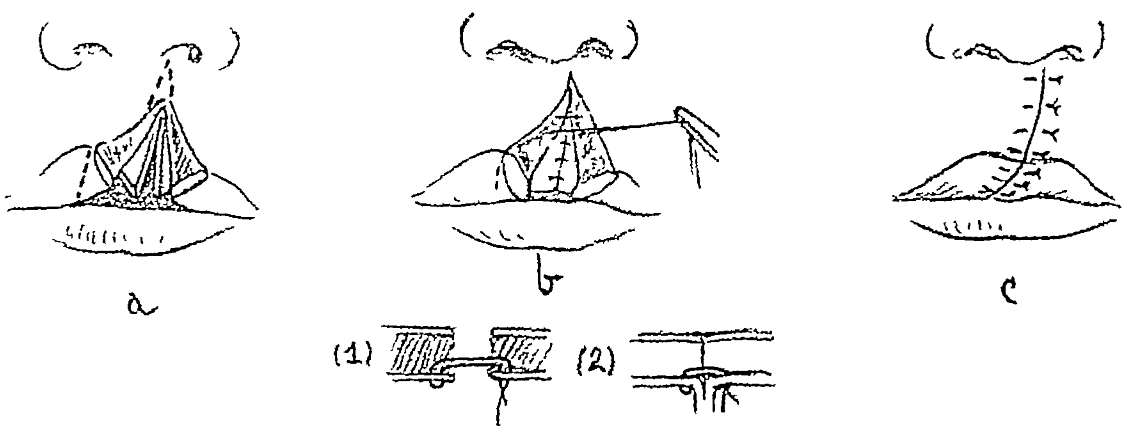


FIG 726 Closure of unilateral cleft *a*, dotted lines indicate tissue sacrificed Mucosal flaps separated from cleft margin and turned inward *b*, mucosal flaps united with on-end mattress sutures, knots lying on lingual side Muscle segments united as separate layer Inserts *1* and *2* show effect of mucosal sutures when tied *c*, skin and vermilion border united with on-end mattress sutures (Kirschner)

from the cleft margins are then trimmed, so that when approximated a prolabial tubercle will be formed to compensate for subsequent contraction Depending upon the conditions found, this is done either by an imbrication of the ends or by a staggering of the line of incision Finally, the balance of the skin sutures are placed and tied without tension Should blanching take place, it is an indication for the immediate removal of the offending stitch As a precaution against crusting, which is apt to occur around long suture ends, they are tied 4 or 5 times and cut close to the knot

Following closure the wound is either left exposed to the air—the scale of the healing surface being relied upon for protection—or painted with Whitehead's varnish As in the case of all operations about the mouth, dressings are best omitted, as they soon become soiled with saliva and milk A Logan tension-bow is applied to draw the two halves of the lip together and thus prevent any strain on the sutures (fig 730), and this is left on for several days Inasmuch as a clean suture line is essential to the prevention of infection, the formation of crusts is guarded against by a frequent swabbing of the part with gauze dipped in normal salt solution followed by the application of zinc oxid ointment.

Alternate skin sutures are removed on the third day and the balance on the fourth and fifth days If a wire muscle suture was used it is withdrawn on the tenth day

Operations for Unilateral Prealveolar Clefts

Space will not permit of a description of even a few of the many operations which have been devised for the repair of these defects, nor would such an account be necessary, since the following procedures embody all the principles in use today and, with a proper understanding of the problem involved, may be modified to meet any demand

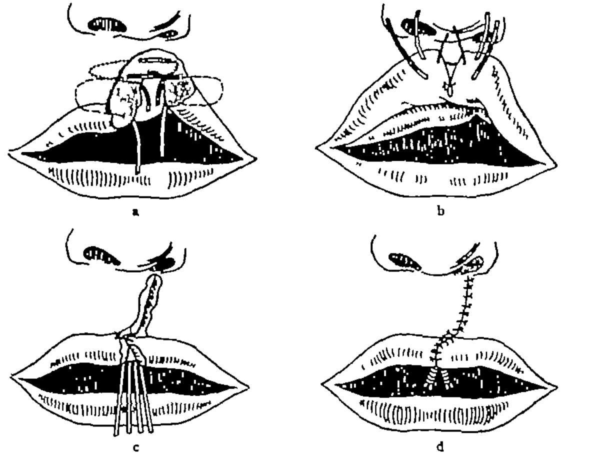


Fig 727 Closure of unilateral cleft with aluminum bronze wire muscle suture. *a*, wire passed through substance of orbicularis oris muscle. *b* lip everted with aid of wire sutures and under surface of mucosa approximated *c*, lip turned down and skin sutured *d* skin sutures completed, and wire muscle sutures tightened (Veau)

Veau s Operation

Veau s operation (71) produces a well-balanced lip with a central fulness which closely resembles the normal

Three cardinal points are marked out on the lip, as follows (fig 728-(1)) Point 1 represents the junction of the column of the philtrum with the vermilion border on the unaffected side of the lip Point 2 represents a corresponding point on the medial side of the cleft where the column of the philtrum merges with the vermilion border on that side On the lateral border of the cleft, Point 3 is so planned that when approximated to Point 2 the height of the reconstructed column will equal the height of the column on the unaffected side

Management of Lateral Margin of Cleft (1) At Point 3 the lip is fixed to the bone by means of a twin-needle devised by the operator The instrument is made to straddle the mucocutaneous junction, the upper point passing through the skin and the lower

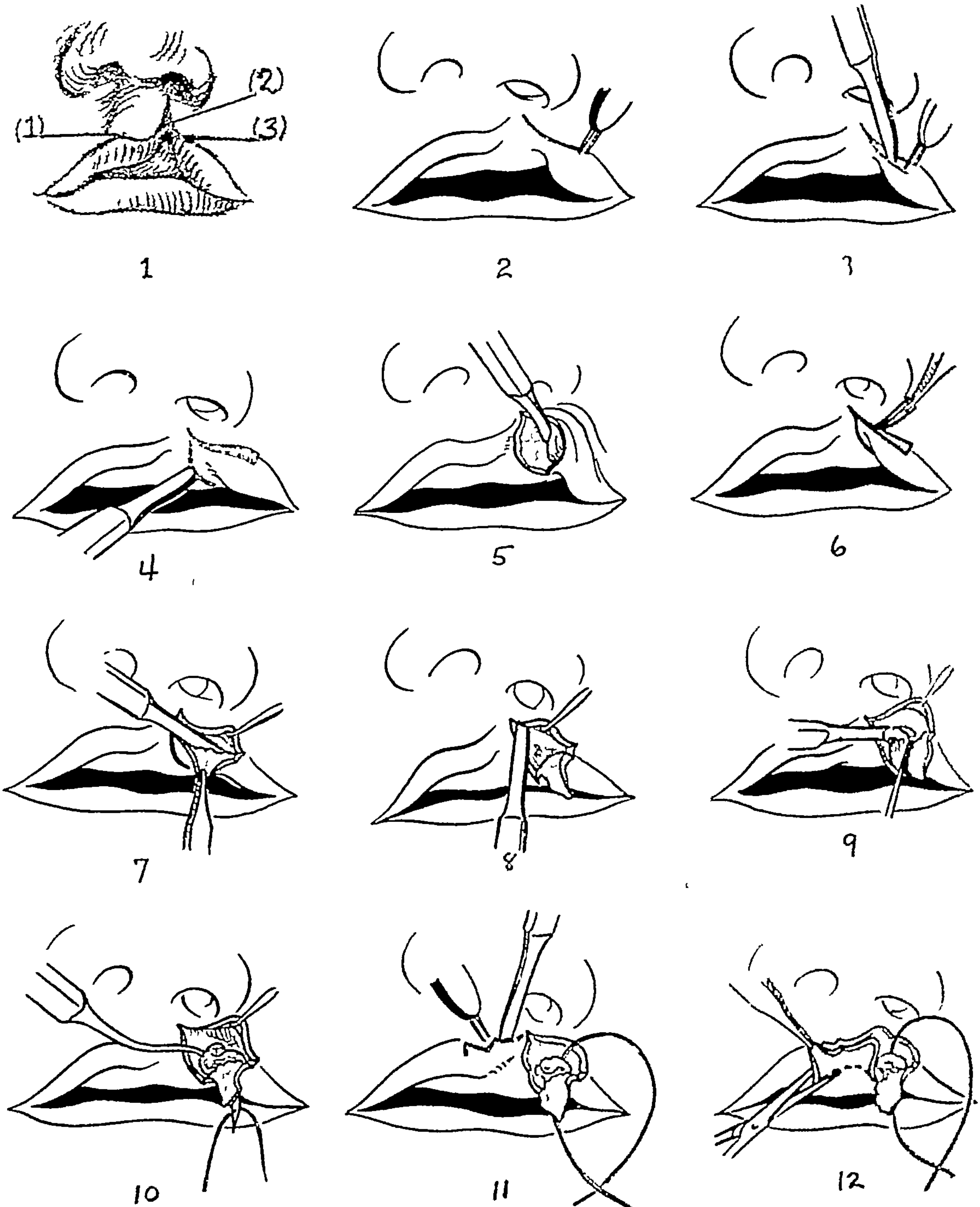


FIG 728 Veau operation for unilateral prealveolar cleft For details, see text (Récamier)

point through the mucous membrane From the upper needle an incision is carried in the skin at a distance of 1 mm from the mucocutaneous junction to the summit of the cleft (fig 728-(2)). From the lower needle a second incision is directed upward in the mucous membrane to join the first (fig. 728-(3)) The tissue between the two points

of the twin-needle is then incised (fig 728-(4)) A long thin triangle, consisting of skin and mucous membrane and with its apex at the summit of the cleft, is thus outlined, to be removed at a later stage. The purpose of this denudation is to prevent the incorporation of the vermilion border in the skin or vice versa when the margins of the cleft are approximated—an error likely to result when an attempt is made to incise the tissues exactly along the mucocutaneous junction. (2) The mucocutaneous triangle having been outlined, the twin needle is removed, the lip is everted, and an incision is made in the mucous membrane beginning at the lower gingivolabial sulcus and passing upward to the summit of the cleft to meet the skin incision previously made (fig 728-(4)) (3) Through the mucosal incision a periosteal elevator is introduced, and the soft tissues including the ala of the nose on the affected side, are separated from the maxilla (fig 728-(5)) The separation is continued until the margins of the cleft can be brought together without tension and the nose made to assume its normal position. (4) The small mucocutaneous triangle previously outlined is excised (fig 728-(6)) There now remains a V-shaped incision with its apex at the summit of the cleft. (5) The mucosa between the limbs of the V is dissected up in the submucosal plane (fig 728-(7)) This dissection will be tedious, as the membrane is very fragile and easily perforated, and great care must be taken to avoid buttonholing it. (6) The upper cutaneous lip of the wound is undermined for a few millimeters to expose the spread out fibers of the orbicularis muscle (fig 728-(8)) As in the mucosal separation, great care must be exercised to avoid puncture of the skin—an accident which would result in additional scarring When the skin has been liberated, the muscle fibers are carefully sought, separated from their faulty attachments to the alar base, and collected together in the form of a bundle (fig 728-(9)) Through the substance of the muscle bundle a Reverdin needle is passed and brought out through the mucous membrane a few millimeters from the gingivolabial junction (fig 728-(10)) The eye of the needle is threaded with a bronze wire and the needle withdrawn, the wire being left in place (fig 728-(11)) This wire will be used later for the approximation of the two halves of the muscle.

Management of Medial Margin of Cleft (1) At Point 2 previously marked out—i e., where the philtrum passes into the vermilion border—the lip is fixed to the bone by means of the twin-needle in the same manner as before. The tissue between the two needle points is incised, and from the upper point an incision is carried upward in the skin along the margin of the cleft to its summit, where it meets the incision made on the lateral side of the cleft. From the lower needle point another incision is carried 1 mm below the mucocutaneous junction, to terminate below the central part of the philtrum (fig 728-(11)) Here the knife is turned at right angles, and the incision is continued back to the frenulum (2) A part of the mucosal flap thus outlined is dissected up and excised as illustrated in Figure 728-(12) enough being left attached to permit of subsequent anchorage of the mucosal flap on the lateral side of the cleft.

(3) To expose the orbicularis oris muscle on the medial side of the cleft, the skin along the upper margin of the incision is undermined for a few millimeters (fig 729-(13)), and the end of the muscle is freed from its abnormal attachment to the bone as before (fig 729-(14)) (4) Through the end of the muscle thus liberated a Reverdin needle is passed from above downward to emerge through the mucosa a few millimeters from the gingivolabial fornix. The point is threaded with a loop of silk and withdrawn, the loop being left projecting in the cleft (fig 729-(15)) This loop will later be used as a guide to complete the passage of the wire suture

future level of the vermilion border on the opposite side   Finally, Point B′ is pricked on the upper part of the mucocutaneous line at a distance from C′ equal to BC   The imaginary line A′C′ must be exactly as long as AC if the two sides of the lip are to be of the same length   Should A′C′ be shorter than AC, it is lengthened to the required distance by curving the incision, as illustrated in Figure 730-a

The above six points having been marked out, an incision is made in the gingivolabial groove on either side of the cleft, and through this incision the cheek, ala, and columella are separated from the maxillae, the dissection being carried well into the cheek, especially on the outer side of the cleft (fig. 730-a)   The greater the deformity, the more extensive the mobilization necessary   Hemorrhage is controlled by pressure with gauze pads

The vermilion border on the medial side of the cleft is now partially separated by means of the incision ACB made through the entire thickness of the lip border (fig 730-b).   The flap is left attached until a decision has been reached as to the amount of material required for the completion of the reconstruction   On the lateral side a similar incision is made connecting A′C′B′ (fig 730-b)   At B′ the knife is directed upward along the mucocutaneous junction to form a small flap of mucosa   The portion of tissue attached above to the ala on the lateral side of the cleft is employed later in the reconstruction of the floor of the nose   Two or 3 sutures of #00 catgut are passed through the ala and the ends of the orbicularis muscle and are tied to bring the ala toward the columella

Three trial silk sutures are now passed between the Points A A′, C C′, and B B′ (fig. 730-c)   The first 2 sutures are completed, and the flap of tissue attached to the ala is rotated upward and inward and pared to form the floor of the nose   Before the completion of the suture at BB′ the mucosal tags are trimmed in such a fashion that there is produced a prolabial tubercle sufficient to compensate for subsequent contraction   This is accomplished by cutting the tag on the medial side obliquely, and carrying the lateral tag over to meet it in the form of a flap (fig 730-d).   The lip is everted, and the mucosa and muscle on the inner surface of the cleft are united by 2 or 3 mattress-sutures of #00 catgut   The lip is then turned down, and the margins of the skin and vermilion border between the cardinal sutures on the external surface are coapted with fine silk   Finally, a Logan tension-bow is applied (fig 730-e)

Rose and Thompson Operations

The Rose and Thompson operations are similar in principle   Both contemplate a simple trimming of the cleft margins, with a view to equalizing the length of the two sides of the cleft   These procedures find their greatest usefulness in the correction of narrow clefts and can often be used to advantage in the secondary repair of a lip following a poor primary reconstruction   For wide clefts, however, they are unsatisfactory since they leave the lip too long vertically and too tight from side to side, cause a scar more conspicuous than that obtained by the Blair-Mirault operation, and fail to provide an adequate floor for the nostrils

In the Rose (74) operation the borders of the cleft are pared in an arched manner, so that when the two concave surfaces are united, the vertical length of the lip will be increased at the site of the suture line   The principle is well illustrated in Figure

731 The incisions AC and A′C′ are of equal length and are arched to such a degree that after coaptation of the margins the desired vertical height will be provided

The Thompson (84) operation is begun by the marking out of cardinal points with a pair of sharp-pointed calipers. The instrument is opened one leg of it is placed at the summit of the cleft, and the other at a point where the free edge of the lip would lie if there were no cleft. With the calipers fixed in this position, the lower limb is swung to the skin vermilion junction on one side of the cleft, at which point a nick is made It is then rotated to the other side and a similar nick made The general plan is shown in Figure 732 YZ represents the desired vertical height of the lip, and ZX the measured width of the vermilion border AB, A′B′, and YZ are of equal length, and BC and B′C′ equal ZX.

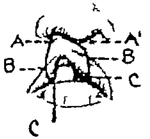


Fig 731

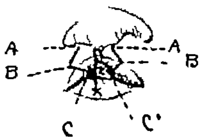


Fig. 732

Fig. 731. Rose operation for unilateral prealveolar cleft. Incisions AC and $A'C'$ of equal length and so arched that desired vertical height will be provided. $BC = B'C'$

Fig. 732. Thompson operation for unilateral prealveolar cleft. YZ represents desired vertical height of lip ZX measured width of vermilion border AB $A'B'$ and YZ of equal length. BC and $B'C' = ZX$

Operations for Bilateral Prealveolar Clefts

Bilateral prealveolar clefts are often easier to correct than unilateral, since as a rule they are symmetrically placed, their margins are less divergent, and the septum, alae, columella, and philtrum are well formed. The repair is carried out in the same manner as that of unilateral clefts (fig 733) If the margins are widely separated, it may be of advantage to unite them in two stages 3 to 4 weeks apart, the larger cleft being attended to first.

POSTALVEOLAR CLEFTS

The surgical aims in the repair of postalveolar clefts are twofold (1) To close off the oronasal communication, with a view to an improvement in respiration deglutition, and oral hygiene, and (2) to provide a mechanism that will assure normal speech Obliteration of the opening offers little difficulty, and in recent years the technic for its accomplishment has been brought to a high degree of excellence. But unfortunately an operation that effects a mere closure of the cleft, no matter how perfect the anatomic result, is in itself of little consequence, since an artificial obturator would serve the purpose nearly as well. The problem lies in the reconstruction of a nasopharyngeal sphincter that will prevent leakage of air into the nose during phonation, and as yet no operation has been devised which will guarantee this result. Indeed, Veau (88) questions whether we shall 'ever know how to operate upon a cleft palate with as

much security as upon inguinal hernia." He (87, 88) estimates that normal speech occurs in 27 8 per cent of cases, and improved speech in 47 per cent. The reason for these poor results cannot be attributed wholly to the operative reconstruction of the palate The outcome depends as much upon the determination and intelligence of the patient, as is shown by the fact that good enunciation sometimes follows an ineffectual repair, whereas grossly defective phonation not infrequently occurs after an excellent anatomic closure In these latter instances it is possible that cranial and cerebral changes over which the surgeon has no control are the factors responsible for the poor results The outlook for normal speech following surgery in the case of older patients is less promising than in infants, since these individuals have learned to speak

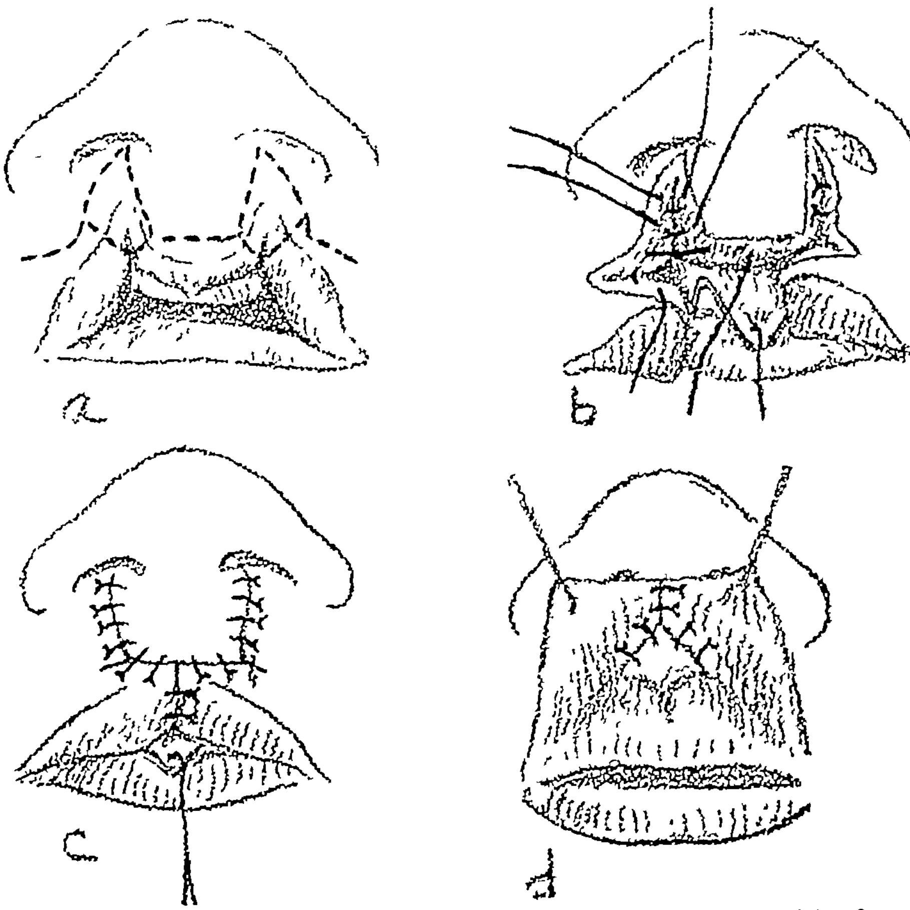


Fig 733 Veau operation for bilateral prealveolar cleft *a*, incision outlined by dotted lines. *b* muscle suture placed *c*, skin margins approximated *d*, mucous membrane approximated (Kilner)

with an incorrect mechanism and a wrong method of breathing, and such faulty habits can be overcome only with the greatest difficulty

A review of some of the early efforts to solve the cleft palate problem will do much to illustrate the principles upon which the modern operation is based According to Dorrance (27), the first to attempt closure of a cleft soft palate was Le Mormier. Dorrance quotes from Robert's report of the operation. "M Le Mormier, a skillful dentist, succeeded in reuniting the borders of the cleft by first inserting several points of suture in order to keep them approximated and afterward abraded them with the 'actual cautery.' An inflammation supervened, terminated in suppuration, and was followed by reunion of the lips of the artificial wound. The child was perfectly cured." Le Mor-

mier's operation, however, attracted little attention until the early part of the nineteenth century when it was revived in Germany by von Graefe (1816), in France by Roux (1819), in America by Warren (1820), and in England by Fergusson (1843)

Dieffenbach (1834) and von Langenbeck (1861) independently reported success in the use of advancement flaps of mucoperiosteum for the repair of clefts involving both soft and hard palates. The steps of the operation were essentially as follows On either side of the palate a mucoperiosteal incision was made between the alveolar arch and the great palatine artery Through these incisions the mucoperiosteum was elevated from the bone up to the cleft. The nasal surface of the soft palate was detached from the posterior margin of the hard palate. The margins of the cleft were pared and the mucoperiosteal flaps shifted into the midline and united (fig 758) The chief drawbacks of the operation were that (1) the lack of epithelial cover on the nasal side of the flap gave rise to scar tissue contraction, (2) the detachment of the soft palate from the posterior edge of the hard palate created a dead space between the flap and the bone, which led to non-union, (3) the bringing of the flaps to the midline unavoidably shortened the soft palate anteroposteriorly and thus prevented palatopharyngeal closure necessary for speech, and (4) the raw surface left on the bone had a tendency to interfere with the development of the upper jaw and teeth

Since the introduction of this procedure many modifications have been made, each with a view to overcoming one or more of its objectionable features. Thus, an epithelial cover has been provided for the nasal side of the flap by a splitting of the tissues on the margins of the cleft into a nasal and buccal leaf, and suturing them separately This manoeuver not only eliminates the consequences arising from the raw area on the nasal surface, but also conserves the marginal tissue (36, 42, 48, 87) In an effort to relieve the shortening effect and the pull of the tensor palati muscle on the soft palate occasioned by the approximation of the tissues in the midline, Billroth (1861) made the suggestion that the hamular processes to which the muscle is attached be sectioned across their bases. Dorrance (27) believes that in this way the muscle is converted from a tensor into an elevator of the palate

In 1894 Davies-Colley (18) introduced a new technic whereby an epithelial lining was furnished as well as a cover Two mucoperiosteal flaps were raised on either side of the cleft. One was pedicled along the cleft margin and turned over the defect, mucosal side in, to serve as lining The other, taken from the opposite side and pedicled posteriorly, was swung over the raw surface of the lining flap for cover (fig 734) Lane (50 52) later enlarged upon the Davies-Colley operation thus A flap of mucoperiosteum, pedicled on the margin of the defect, was separated from the palate, turned over hinge fashion, raw surface facing the mouth, and inserted into a pocket made under the mucous membrane of the opposite side While these methods were capable of effecting closure of wide clefts without tension entailed no sacrifice of marginal tissue, and gave better assurance of union, owing to the fact that large raw surfaces were brought in contact, nevertheless they found few adherents, due to several objectionable features The mortality was high, owing to the radical nature of the operation there was danger of necrosis, since the flaps were planned without regard for the course of the blood vessels, and a large denuded area was left on the palate to undergo contraction, with its tendency to narrow the arch and interfere with the eruption of the teeth

Closure has also been accomplished by mobilization and approximation of the bone

on either side of the cleft (26, 33, 41, 53, 97) Such procedures were tempting, in that they gave good immediate results, the nasal surfaces of the flaps were covered with mucous membrane, and the flexibility and length of the soft palate were preserved, since its muscular attachments were not injured Nevertheless, the methods did not meet with much favor because of the severity of the operation, the danger of bone necrosis, of injury to the tooth buds, and of interference with the development of the alveolar arch; and so they were abandoned in the first part of the nineteenth century

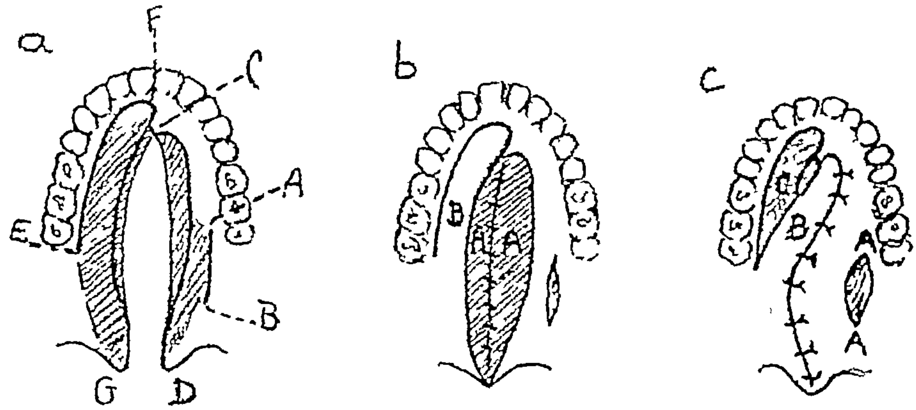


FIG 734 Davies-Colley principle of supplying lining in cleft palate operation *a*, line *AB* indicates incision for cutting tensor palati muscle, *CD*, incision for mucoperiosteal flap, to be turned in as lining, *EFG*, incision for covering flap *b*, *A*, flap turned over and sutured to pared margins of defect, to form lining *B*, covering flap *c*, *AA*, relaxation incision, *B*, flap rotated inward, to supply cover, *C*, raw area (Davis)

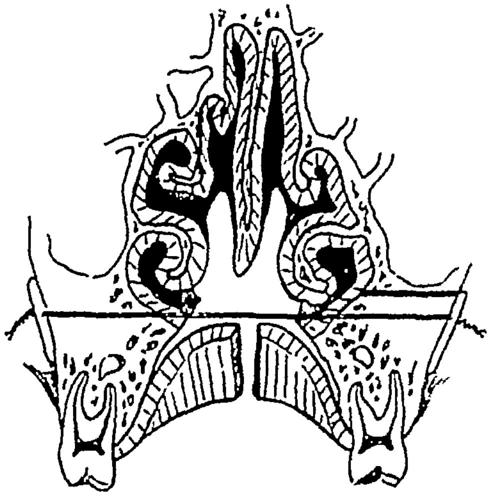


FIG 735 Repair of cleft palate by mobilization and approximation of bones on either side of cleft Diagram illustrates course of wires passed through maxillae Ends passed through lead plates and tightened For details, see text (Brophy)

Obliteration of the cleft by manipulation of the bone was revived, however, and popularized by Brophy at the beginning of the present century

Brophy (14) proceeded on the assumption that the width of the cleft was equal to the spread of the maxillae, and his operation consisted essentially in closure of the cleft by forcible compression of the bones His technic is as follows (fig 735): The margins of the cleft are pared, and with the cheek everted a specially designed needle, armed with a loop of silk thread, is passed transversely through the maxilla in the plane lying between the palate and the floor of the orbit. When the needle appears in the cleft, the thread is picked up with a forceps and the needle withdrawn, the loop being left in the

opening A loop is then passed through the maxilla on the opposite side in like manner One loop is threaded through the other, and by the exertion of traction on one pair of ends, the thread is drawn through the opposite maxilla. With this suture serving as a pilot, a # 20 silver wire is carried through the bones. By a similar procedure another wire is then passed through the anterior part of the cleft. The maxillae are compressed digitally, until the cleft is obliterated, after which the bones are immobilized by a tightening of the previously passed wires over lead plates on the outer aspects of the jaw Finally, the edges of the cleft are united. The wires are removed at the end of 3 or 4 weeks.

Neumann (63) drew the bones together with metal clamps anchored on the outer aspect of the maxillae above the tooth germs. These clamps were tightened every few days, until closure of the cleft was obtained. Recently Davis (22) has revived a procedure originally devised by Fergusson The operation is performed in 2 stages 5 to 8 days apart. In the first stage the palatal processes are detached, and in the second the cleft margins are pared and sutured together

All of the above procedures were successful in securing an anatomic closure and thus improved deglutition, respiration, and oral hygiene. But they did little to improve the defective speech—the main if not the only purpose of the operation—since the mobilization and shifting of the tissues toward the midline, together with the subsequent scar tissue contraction, reduced the length of the already short soft palate. Accordingly, attention was now focused on means to effect an improvement in phonation.

On the premise that the defect in speech is caused either by a shortening in the anteroposterior length of the palate or an increase in the dimensions of the pharynx, methods were devised (1) *to lengthen the palate*, (2) *to bring forward the posterior pharyngeal wall*, and (3) *to reduce the circumference of the pharynx*, with a view to making possible the closing off of the nasopharynx during phonation.

Lengthening of the palate was attempted by the addition of tissue in the form of flaps taken from the pillars of the fauces, the tonsillar area, cheek, and posterior pharyngeal wall (75, 79) Even extra-oral tissue was employed for the purpose (8, 10, 11, 31, 65, 76, 83) But these procedures merely supplied functionless material which caused further interference with the free movement of the palate (39) and failed to improve speech

Other procedures have been designed, envisaging the displacement of the entire palate backward (32, 43 57) A well-known example of this type of operation is the "pushback operation' of Dorrance (28), based on the principle of the delayed flap, and performed in two stages, as follows (fig 736) *First stage* Through an encircling incision around the alveolar arch the mucoperiosteum of the hard palate is raised in the form of a flap, the posterior palatine arteries being divided in the process The flap is temporarily sutured back in place, until a collateral circulation has developed. *Second stage* About 3 months later the mucoperiosteal flap is again elevated through the original incision, the soft palate is separated from the hard palate through an incision in the nasal mucosa and palatine aponeurosis along the posterior margin of the hard palate, the hamular processes are fractured, and the extremities of the encircling incision are extended around the maxillary tuberosity The whole mass, now completely freed is pushed back The borders of the cleft are split into an oral and a nasal leaf The nasal mucosa is separated from the bone for a distance sufficient to permit of tensionless approximation. With a Reverdin needle a wire suture is passed

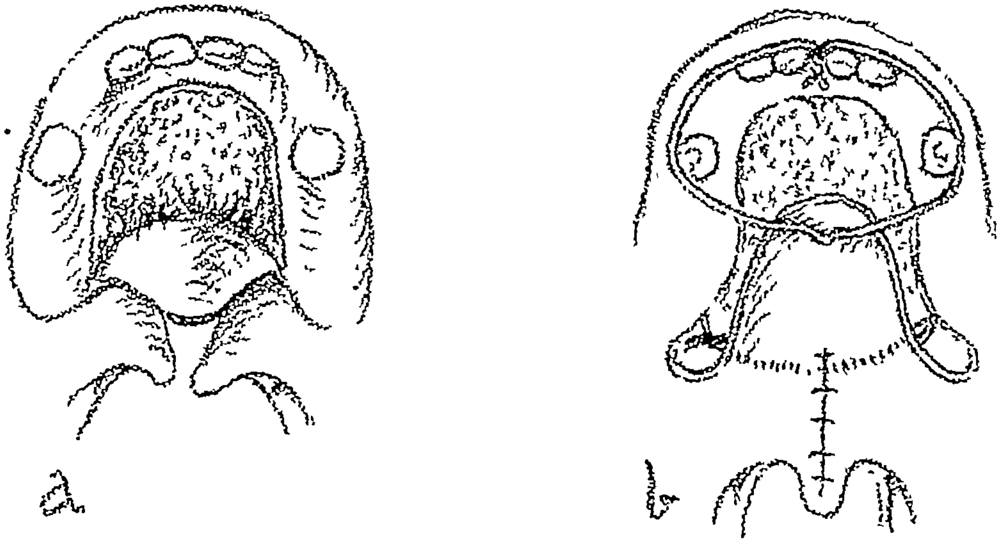


Fig 736 Lengthening of palate by backward displacement. Dorrance "pushback" operation. *a*, mucoperiosteal flap separated from bone as far back as palatal aponeurosis Flap replaced in original position, to enhance its nutrition *b*, at second stage 3 months later, flap again raised, and palate pushed back. Cleft repaired Aluminum bronze tension suture passed around muscle Flap held in place by silver wire applied around teeth and across palate (Horsley-Bigger)

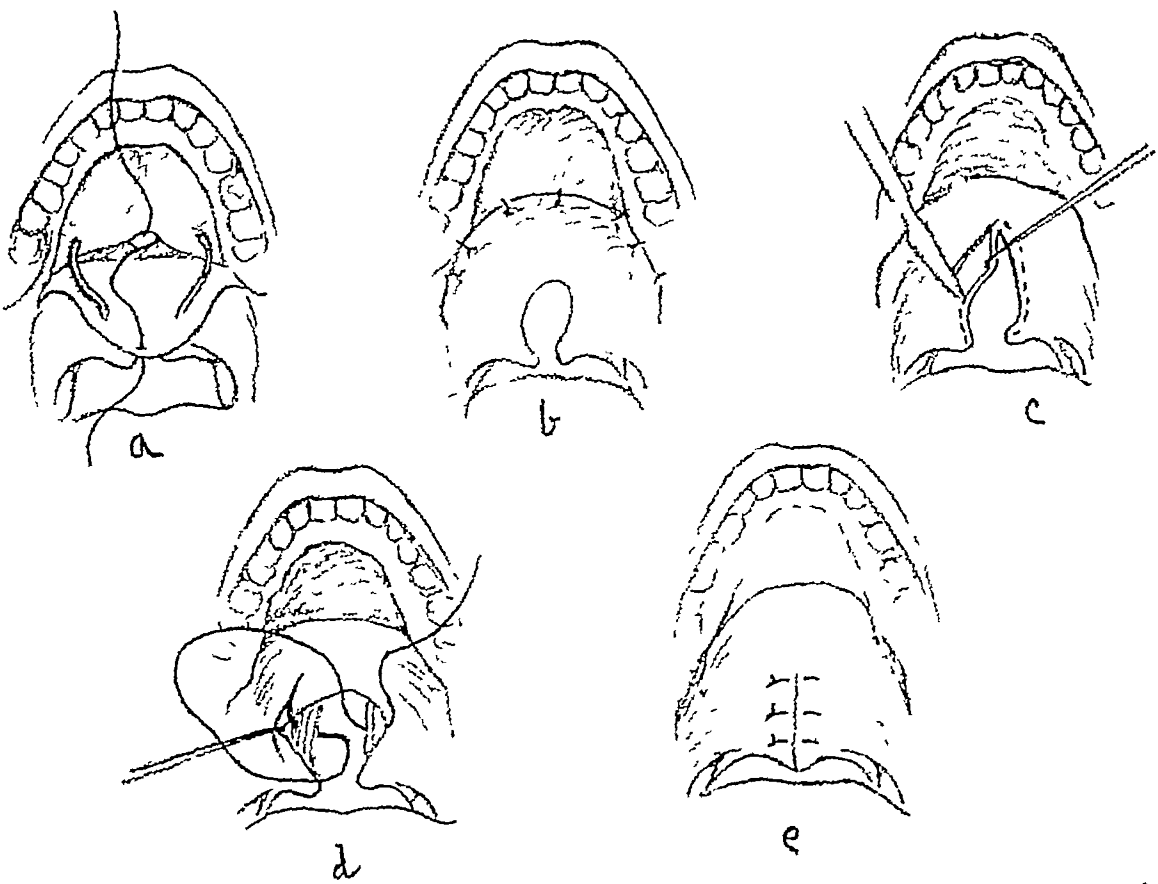


Fig 737 Lengthening of palate by backward displacement Browne operation *a*, mucoperiosteal flap elevated Major palatine arteries preserved Soft palate separated from hard palate Strip of nasal mucosa conserved, to be used as point of anchorage for suture *b*, palate set back and anchored with horsehair sutures *c*, at second stage, margins of cleft pared *d*, stay-suture placed and tied on nasal surface *e*, cleft closed with on-end mattress-suture

around the muscle of the soft palate in the same manner as in Veau's operation (p 1147) The flaps of nasal mucosa previously separated are sutured together in the midline The wire suture is tied The mucoperiosteal flap is replaced and fixed to the palate by means of sutures passing through any available soft tissue or through the bone.

Browne operates in a similar manner but preserves the posterior palatine artery (fig 737) At the first operation an incision is made along the anterior pillar and extended to the maxillary tuberosity, where it curves around the palate close to the alveolus and terminates at a point opposite the initial incision. The mucoperiosteal flap thus outlined is elevated, the major palatine arteries being carefully preserved. When the posterior edge of the hard palate is reached, the nasal mucosa is opened, and a narrow margin of it is left attached to the bone, to be used subsequently as a point of anchorage for a suture. The aponeurosis on the posterior edge of the hard palate is then divided The arteries are elongated by being stretched from their foramina,

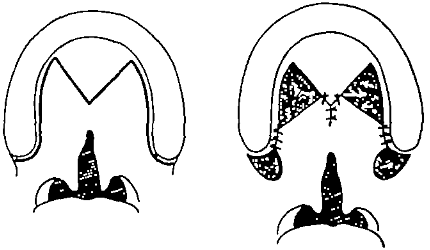


FIG. 738. Lengthening of palate by backward displacement. Moorehead operation *a*, mucoperiosteal flap outlined by incision. *b* flap raised and shifted backward tips sutured to apex of V-shaped section on anterior part of palate.

and the entire mass is sutured to the posterior bony margin of the palate. At the second stage the margins of the cleft are trimmed and united.

Moorehead elongates the soft palate as follows (fig 738) A mucoperiosteal flap is raised from the palate by means of an M-shaped incision. The flap thus mobilized is shifted backward and the tips sutured to the apex of the V-shaped section of mucoperiosteum left on the anterior part of the palate.

While these procedures are advantageous in that they lengthen the palate and can be used in combination with other methods for palatal closure, they leave on the nasal aspect posterior to the bony palate a large raw surface which is subject to infection and cicatrization.

Gillies (38) foregoes anterior closure of the cleft and uses all the available tissue for the reconstruction of the soft palate reasoning that inasmuch as the majority of patients with cleft palate require some sort of dental plate as an adjunct to surgery, the prosthesis may as well be made to carry an obturator that will occlude the palatal opening The technic of his procedure is as follows (fig 739) A mucoperiosteal flap pedicled on the

soft palate, is raised from either side of the hard palate. The soft palate is then partially detached from the hard palate by means of transverse incisions made through its substance and is displaced backward The raw areas remaining on the anterior part of the soft palate are covered with the previously reflected mucoperiosteal flaps In-

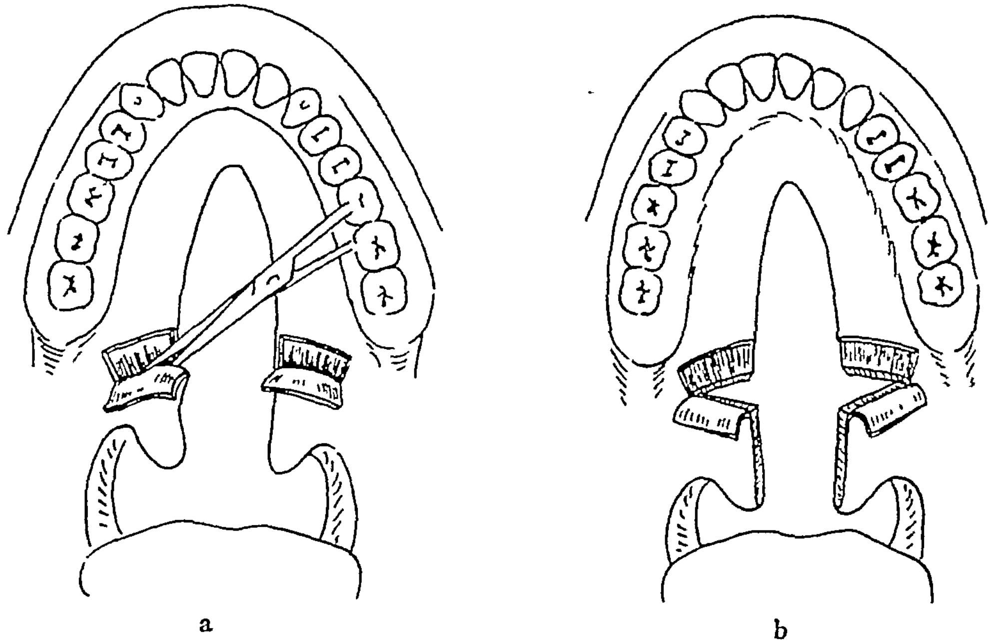


FIG 739 Lengthening of palate by backward displacement Gillies operation *a*, mucoperiosteal flaps raised Soft palate separated from hard palate with scissors *b*, soft palate displaced backward Cleft margins pared and united Flaps previously raised used to cover raw area on anterior part of soft palate

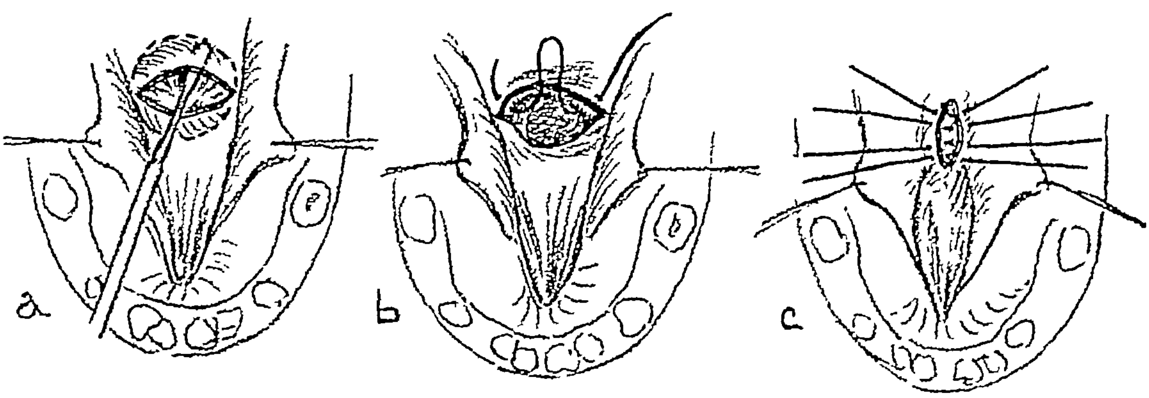


FIG 740 Reduction in circumference of pharynx and construction of permanent muscular buttress on posterior pharyngeal wall Wardill pharyngoplasty *a*, transverse incision made on posterior pharyngeal wall Superior constrictor separated along line of cleavage. *b*, wound closed vertically, as in operation for pyloroplasty Suture passed through salpingopharyngeal folds *c*, when sutures are tied, salpingopharyngeal folds are drawn together, forming a pad, with narrowing of pharynx For details, see text

stead of flaps, a skin graft held in place by a specially constructed prosthesis may be used for the purpose

In an effort to *bring the posterior pharyngeal wall forward* to meet the shortened palate and thus prevent the escape of air into the nasopharynx during phonation, a variety of procedures have been proposed Among these were the submucosal injection of paraffin (30, 94), the introduction of fat, fascia, and cartilage grafts (37), and the reefing

of the mucous membrane of the pharynx on itself (66) These operations proved of some benefit but involved many hazards and have been alternately used and discarded.

For the reduction of the circumference of the pharynx various forms of pharyngoplasty have been designed—i.e., transverse incisions in the posterior wall followed by longitudinal suturing (77), excisions of elliptic sections (13), electrocoagulation (96), and free separation of the lateral pharyngeal walls from the internal pterygoid plate (1, 32)

Recently Wardill (90) has described a promising procedure in which he decreases the width of the pharynx laterally and produces a permanent muscular buttress imitating Passavant's pad on the posterior pharyngeal wall. The technic is as follows (fig 740) With the patient under light anesthesia and the head thrown well back, the pharyngeal reflex is stimulated to cause the superior constrictor to contract, and the position of the ridge is carefully noted. Anesthesia is deepened, and at the level of this ridge, a transverse incision 2 to 3 cm. long is made in the posterior pharyngeal

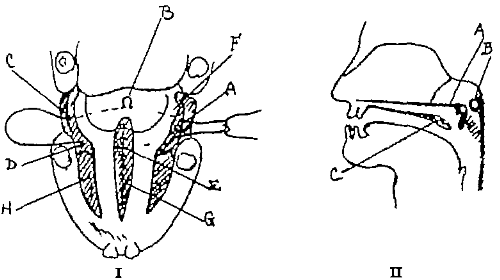


FIG. 741. Reduction in circumference of pharynx by encircling suture. *IA* point of entry of suture; *B* points of emergence and reintroduction *C*, emergence of suture after traversing posterior pharyngeal wall, *D*, point of introduction *E*, suture passing through partially sutured cleft *F* mucosa of anterior pillar *G*, nasal mucosa sutured *H* raw surface. *IIA* soft palate *B* Passavant's ridge *C* position of palate after von Langenbeck operation. White dots show position of encircling suture.

wall. Through this incision the superior constrictor is widely separated along its line of cleavage The lips of the wound are retracted vertically with small hooks and sutured as in the operation of pyloroplasty The suturing is done with a small Mayo needle and #00 catgut, the stitches being placed at a considerable distance from the margins, as a precaution against their tearing out. For the relief of tension during the first few days a suture is passed through the posterior pillars of the fauces.

Browne (15) reduces the diameters of the pharynx by passing an encircling suture around its walls (fig 741)

OPTIMAL TIME FOR OPERATION

In the case of postalveolar clefts some surgeons operate within a few hours after the infant's birth, while others postpone repair up to the fifth year The advocates of early operation contend that subsequent development of the nasopharynx takes place in a more orderly manner, the child responds more satisfactorily to orthodontic treat-

ment, there are no defective speech patterns to be corrected, cheek flaps may be used in the repair without interference from the teeth, and hemorrhage is less troublesome Lane (51) considered the best time for surgery to be "the day after birth or as soon after that as possible The earliest I have done has been within 7 hours after birth Many of the clefts present in those cases can only be closed before the gums are encroached on by the teeth The sooner the nose is separated off from the mouth the earlier the nasopharynx is exposed to the influence of the mechanical factors which normally determine the development of this passage and of the structures which surround it" Those who operate late do so on the grounds that the mortality rate is lower; that anatomic closure is more satisfactory, since the tissues are less fragile and better developed, and that, furthermore, the delay does not impair speech.

While it is impossible to lay down a general rule as to the most suitable time for operation in all cases of cleft palate, it is generally conceded that narrow clefts confined to the soft palate should be repaired as soon as the child's general condition permits, and that the correction of wide clefts involving both the hard and soft palate should be deferred until the tissues have developed sufficiently to permit of tensionless closure—i.e , until about the second year. In any event, these cases should be operated upon before faulty speech patterns and speaking habits have become established Makuen (59) states that "the child begins to build up speech impressions and habits early in the second year, and the more serious forms of speech defects are those that are acquired during the formative period" Veau (87), whose experience gives him the right to speak with authority, believes the period between the tenth and twentieth month to be the most appropriate time for operative interference and bases his conclusions on statistics which show that operations performed in the first year of life show 9 per cent mortality and 70 per cent normal speech; those in the second year, 5 to 6 per cent mortality and 69 per cent normal speech, and those in the third year, practically no mortality, but only 25 per cent normal speech

The repair of clefts involving both the soft and hard palate can usually be performed in one stage, unless the cleft is so wide that complete approximation would jeopardize the line of union Under the latter circumstances, correction is carried out in 2 stages, that of the soft palate taking precedence because of its important bearing on the function of speech

Instruments

The instruments, like those used in cleft lip operations, vary with the preference of the surgeon The following, however, will be found to meet all needs (fig 724): Cleft palate knives—narrow, straight, single, double-edged, curved, angulated, and blunt-pointed, forceps—plain, dissecting, straight, and curved; Reverdin's needles—straight and curved, Trélat's needle; Lane's cleft palate needles and needle holder, cleft palate elevators of various shapes and sizes, tenacula, scissors—straight and curved, sharp and blunt, curved on the flat and rectangular, mouth gag with tongue depressor (the Lane, Davis, and Whitehead models are simple, effectual, and will not slip), Veau's angulated elevators in 3 sizes, sutures—ophthalmic silk, horsehair, 0 1 mm bronze wire, chisel and mallet, suction apparatus, binocular loupe; head lamp

Repair of Clefts Limited to Soft Palate (Staphylorrhaphy)

Since the velum is the part of the palate most concerned with speech and deglutition, the greatest care must be devoted to its repair The operation should leave the palate sufficiently long and flexible to enable it to do its share in closing off the oronasal communication, and this preservation of function is assured only by a technic which inflicts a minimum of injury to the muscles and leaves the least possible amount of scar tissue. The operation which most nearly meets these requirements is that of Veau, it consists in the approximation of the soft palate in 3 layers—pharyngeal mucosa, muscle, and oral mucosa. Of these the muscular suture is the most important, as stressed by Veau (87) "La première est utile, la deuxième est indispensable, la troisième est superflue." This suture, without injuring the muscle, not only serves to relieve tension, but also brings broad raw surfaces into apposition

Veau s Operation

Passage of Wire Muscle Suture. (1) A curved Reverdin needle is introduced on the buccal surface of the right side of the cleft, in a small depression found between the anterior palatine arch and the margin of the maxilla (fig 742 (1)) With its point directed downward, the needle, guided by the left index finger hooked under the pharyngeal aspect of the soft palate, is passed medially in the plane between the muscle and the nasal mucosa, care being taken to avoid perforation of the latter membrane (fig 742 (1)) The point is brought out on the margin of the cleft. Before proceeding further, the surgeon determines by palpation whether all the muscle is encircled in the concavity of the needle. If it is found that some of the fibers have not been incorporated, the instrument is removed and reinserted in the proper plane (2) Before the wire suture is passed, the margin of the cleft is split—a detail most conveniently carried out at this time, since advantage may be taken of the Reverdin needle to aid in the fixation of the flexible velum. The instrument is lifted, to put the tissues on stretch, and the incision is begun at a point just posterior to it and carried along the cleft margin to the tip of the uvula. The position of the needle is now changed, so that the anterior part of the palate is put on stretch, and the incision is continued to the anterior extremity of the cleft (fig 742-(2),(3)) Care should be taken that the entire cleft border is incised, for any mucosa left intact will result in failure of union at that point. (3) The needle is now threaded with a strand of bronze wire and withdrawn, the wire being left in place (fig 742 (4), (5)) The ends of the wire are held with a clamp This wire will later be conducted through the other side of the palate, if passed at this time, it would interfere with the suturing of the nasal mucosa. (4) The same manoeuver is carried out on the left side of the palate the right index finger acting as a guide. Unless the surgeon is ambidextrous, the procedure here will be more difficult, since the manipulations must be performed with the left hand. A change in the operator's position, however, will facilitate his movements. The Reverdin needle is passed as before and made to steady the tissues while the margin of the cleft is split. The needle is then threaded with the two free ends of a loop of silk (fig 743 (9)) and withdrawn, the loop being left in place (fig 743-(10)) to be used later as a guide for the completion of the bronze wire muscle suture.

Suture of Nasal Mucosa. When the cleft margins have been incised throughout their entire extent, the edges of the nasal mucosa are approximated with horsehair

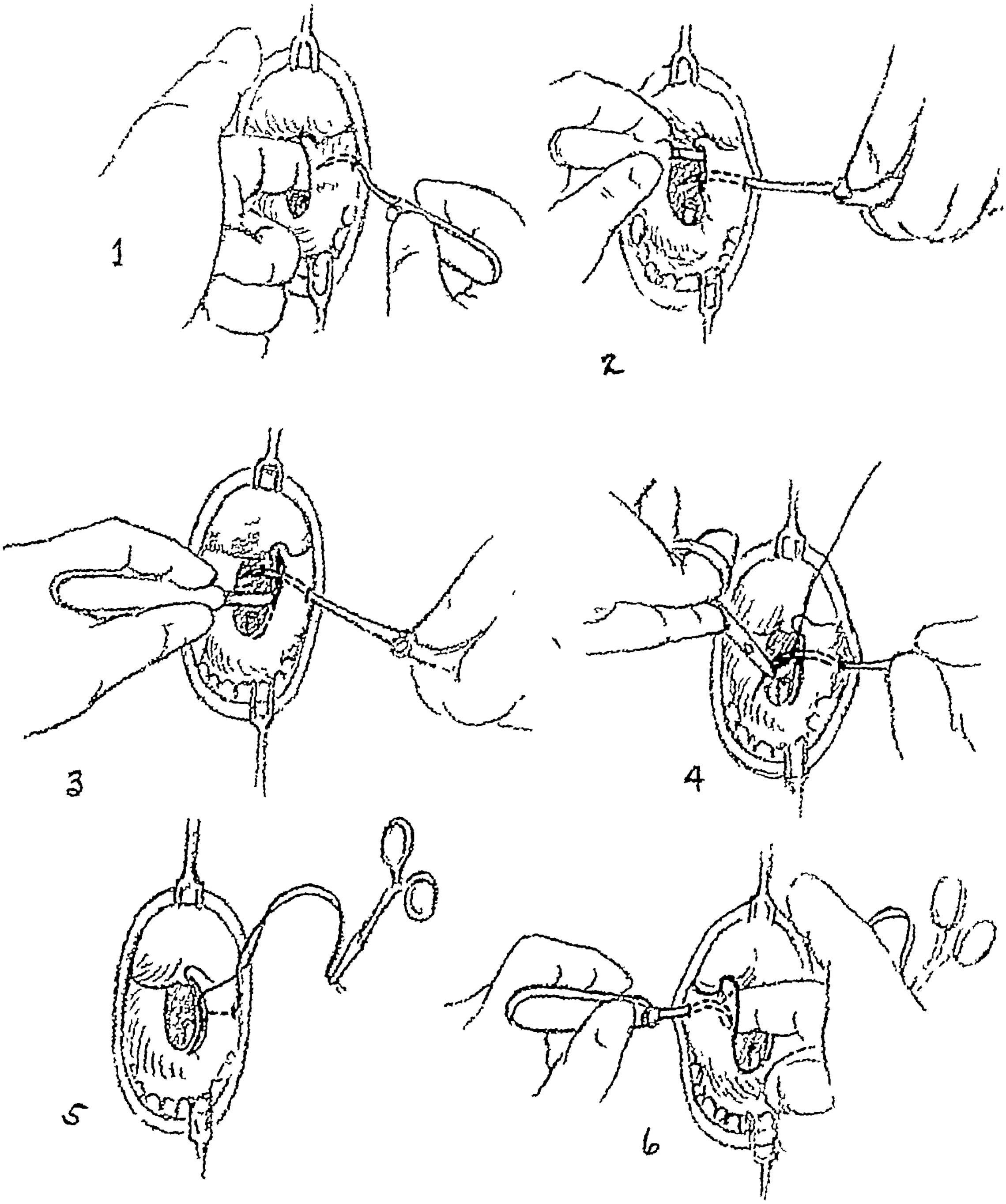


FIG 742 Veau staphylorrhaphy *1*, Reverdin needle introduced on *right* side between pharyngeal mucosa and muscle, *left* index finger guiding needle *2*, *right* side of palate steadied with needle Margin of cleft *in back* of needle separated into buccal and nasal leaf *3*, anterior part of palate put on stretch Margin of cleft *in front* of needle similarly divided *4*, wire suture threaded into needle and withdrawn *5*, wire suture passed Free ends held temporarily with hemostat. (This wire will be used later to encircle the muscle on the other side of the cleft If passed at this time, it would interfere with the suture of the nasal mucosa) *6*, Reverdin needle introduced on left side between pharyngeal mucosa and muscle, *right* index finger guiding needle (See Figure 746)

mounted on a fine Reverdin needle, the instrument being passed threaded, so that the knots will lie on the nasal surface It is made to enter the nasal mucosa on the right side at a point 1 mm from the margin After the membrane has been penetrated,

the thread is drawn from the eye of the needle with a pair of forceps. The other end of the thread is passed through the left margin of the cleft in a similar manner, and the

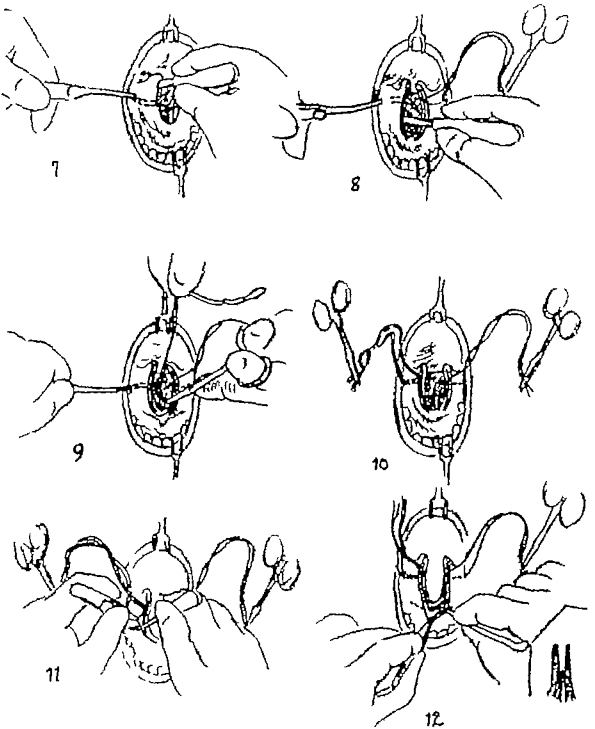


FIG. 743 Veau staphylorrhaphy (cont.) *7* left margin of cleft *in back* of needle separated into buccal and nasal leaf *8*, margin of cleft *in front* of needle similarly treated. (See Figure 747) *9* two ends of silk suture threaded into eye of needle and withdrawn. (This loop will be used later as a pilot to draw the wire suture across the palatal cleft.) *10* ends of silk loop held temporarily with hemostat. *11* buccal mucosa separated from palate with angulated raspatory Dissection continued, separating entire cleft into buccal and nasal leaf *12* showing separation of buccal mucosa at apex of cleft. (This requires care, owing to the fragility of the membrane, and the raspatory must stay close to the bone.)

suture is tied. During this procedure care must be taken to avoid elevation of the membrane by upward tension on the ends of the thread, as this may cause the thread to tear through the tissue. Such an accident will best be avoided if one end of the

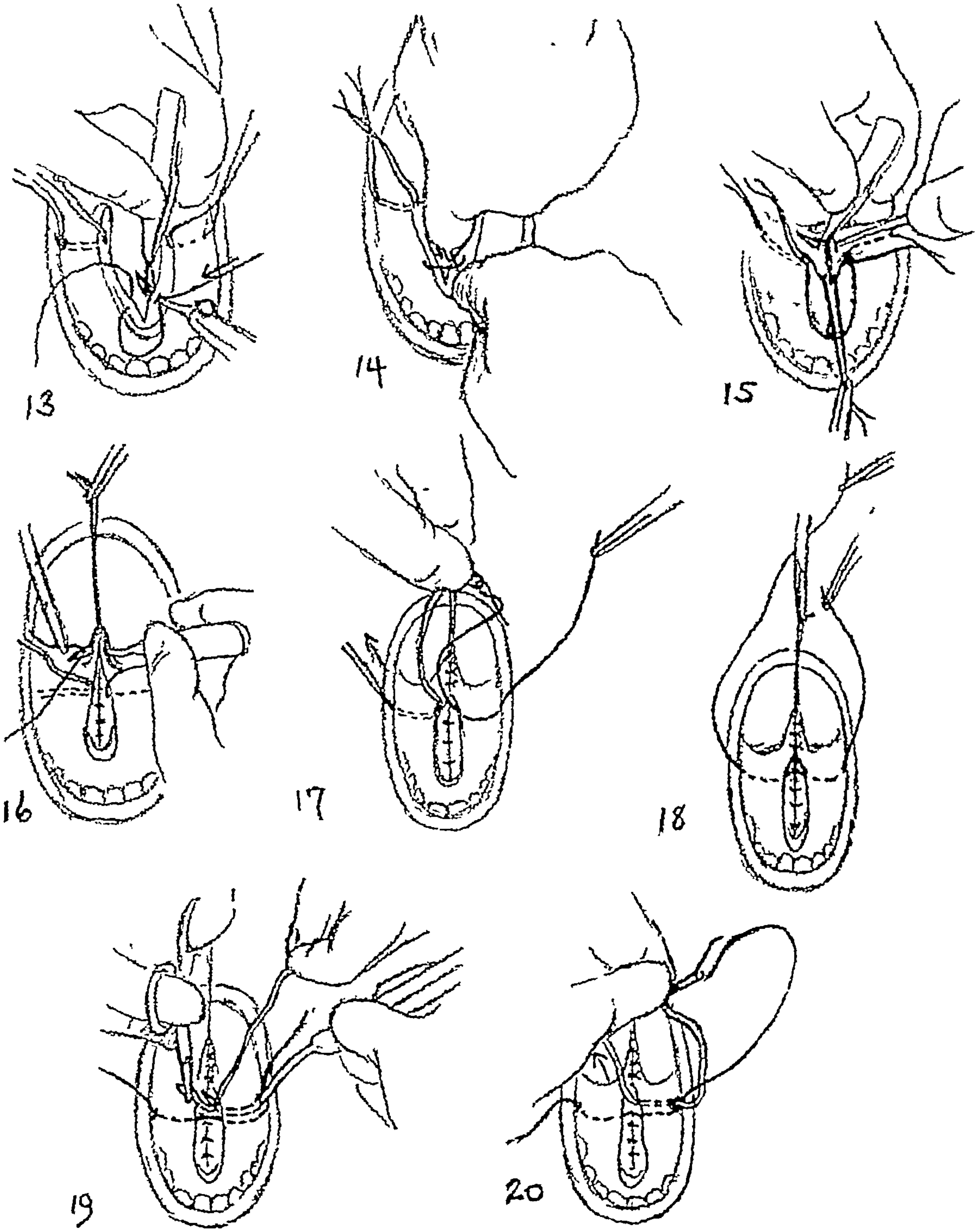


FIG 744 Veau staphylorrhaphy (cont) *13,* nasal mucosa sutured from before backward and in such a manner that knots will lie on nasal side (See Figure 748) *14,* method of tying suture, so that no traction is exerted on mucosa *15,* suture passed through apex of uvula and used as tractor, to expose pharyngeal surface for suturing (See Figures 749–751) *16,* with aid of tractor suture, buccal margins of cleft approximated *17,* end of wire suture hooked into silk loop previously passed and conducted between nasal mucosa and muscle on *left* side (See Figure 752a) *18,* shows wire suture passed between nasal mucosa and muscle on both sides of cleft *19,* method of carrying wire suture between buccal mucosa and muscle on *right* side Reverdin needle introduced at point of emergence of wire suture, carried between buccal mucosa and muscle, and made to issue on cleft margin Needle threaded with loop of silk, which is withdrawn (See Figure 752b) *20,* wire engaged in silk loop and carried into cleft (See Figure 752c)

thread is fixed over the finger in the nasopharynx, while the other end is tightened by the finger outside of the mouth (fig 744-(14)) The suturing is continued until the base of the uvula has been reached (fig 744-(15))

Suture of Uvula. The suturing of the uvula is difficult, owing to the flexibility of the structure. The first stitch is passed through the 2 segments of the divided tip (fig

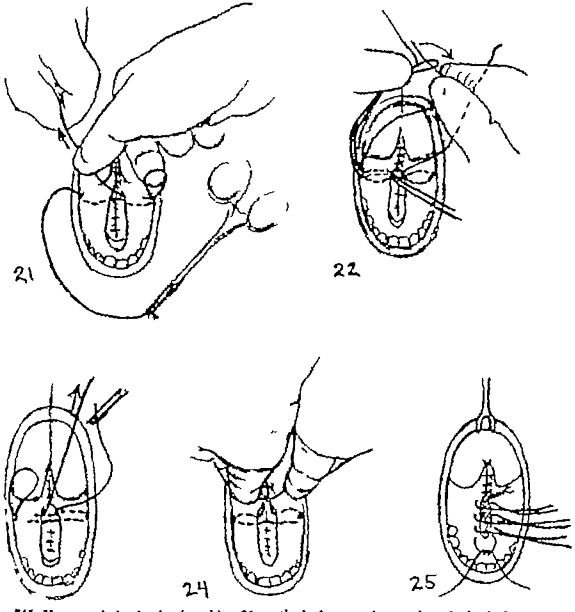
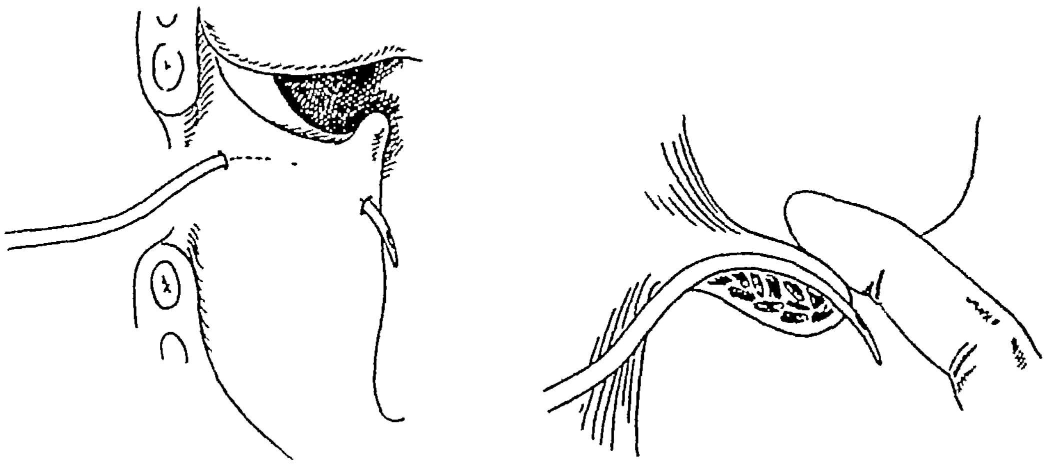


FIG 745 Veau staphylorrhaphy (concl.) *21*, method of preventing torsion of wire in its passage through tissues. *22* wire suture passed between buccal mucosa and muscle on *left* side in similar manner. *23*, wire suture passed around muscle on *both* sides. (See Figure 752d.) *24* wire suture tightened, bringing muscle segments in contact in midline. *25* sutures passed for approximation of buccal mucosa. (Récamier)

744-(15)) With this thread serving as a retractor the uvula is everted to expose the nasal aspect, and the margins are approximated with horsehair (fig 744-(15)) When the entire nasal surface has been closed, the uvula is returned to its original position, and while it is held taut by means of traction exerted on the anchoring stitch, the margins of its buccal surface are approximated, the needle incorporating both borders in each bite (fig 744-(16))

Completion of Muscle Suture. This is the most important step of the operation, since it relieves tension and brings about a wide approximation of the raw surfaces The extremity of the wire protruding from the cleft on the right side is hooked into the loop of silk and is conducted through the left side of the palate by traction exerted on the ends of the silk thread (fig. 744-(17)). The encircling of the muscle is completed by drawing the wire, now lying behind the muscle of the soft palate, between the oral mucous membrane and the muscle, as follows: A Reverdin needle is inserted into the orifice from which the wire projects on the right side and is conducted out into the cleft



a b

FIG 746 Method of passing Reverdin needle. *a*, needle passed in plane between muscle and pharyngeal mucosa *b*, finger hooked under pharyngeal mucosa, to guide course of needle

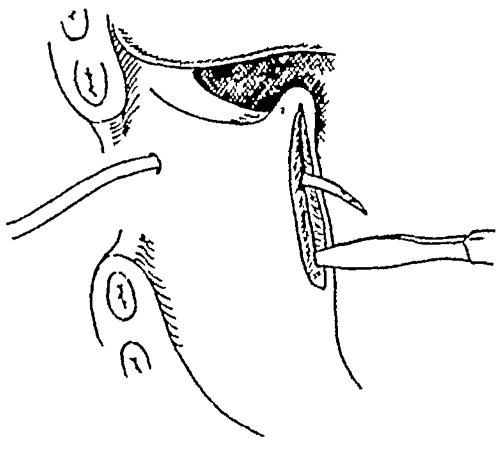


FIG 747 Paring of margins of cleft Palate steadied by needle, and cleft margin split into bucca and nasal leaf

through a plane between the oral mucous membrane and the muscle (fig. 744-(19)) The passage of the needle in this location offers no difficulty, since the instrument is clearly visible A silk loop is now threaded into the eye, and the needle pulled back, carrying the loop with it Into this loop the end of the wire protruding on the right side is hooked and drawn back into the cleft (fig 744-(20)) During this manoeuver great care must be taken to avoid torsion which would tend to cause rupture of the wire, an accident requiring removal of all sutures and a repetition of the entire procedure As a precaution against such a mishap, the index finger is hooked into the wire as the latter is drawn through. The same steps are carried out on the opposite side of the palate,

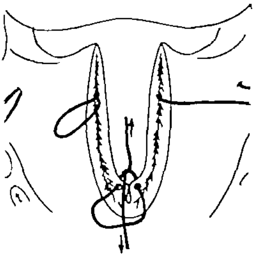


FIG. 748. Method of suturing nasal mucosa, so that knot will be on nasal side. Arrows indicate direction of pull for tightening.

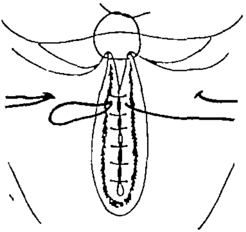


FIG. 749 Suture of uvula. First stitch passed through segments of divided tip and used as tractor for passage of remaining sutures

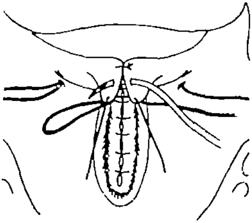


FIG. 750 Suture of uvula (cont.) With aid of tractor suture, uvula everted, and passage of remaining sutures begun.

so that both ends of the wire now appear in the cleft (fig 745-(23)) The wires are tightened, twisted together and the ends cut and bent slightly to prevent injury to the tongue (fig 745-(24))

Suture of Buccal Mucosa. Finally, the buccal mucosa is brought together, on-end mattress-sutures of horsehair being employed for the purpose, so that a wide approximation may be secured (fig 745-(25))

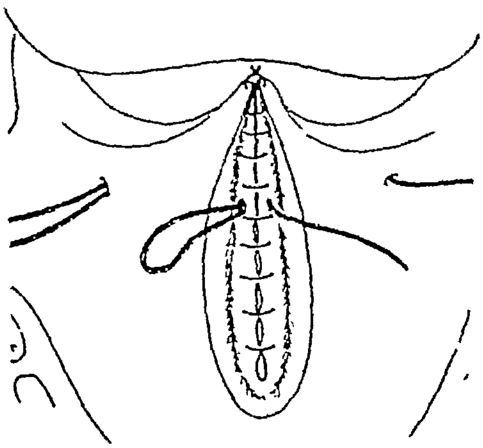


FIG 751 Suture of nasal mucosa completed

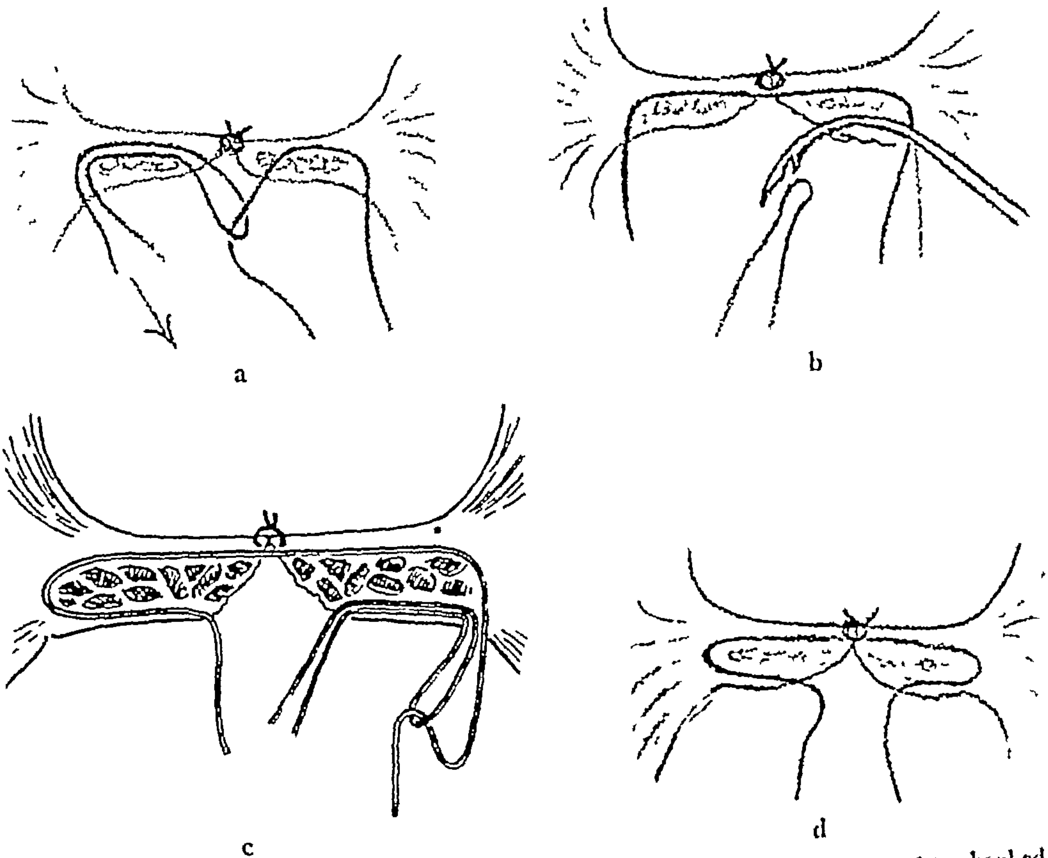


FIG 752 Sectional view, showing completion of wire muscle suture *a*, wire suture hooked into silk loop and withdrawn *b*, wire suture in place between pharyngeal mucosa and muscle Reverdin needle threaded with silk loop, to be used for conducting wire suture between buccal mucosa and muscle, *c*, wire suture hooked into silk loop and withdrawn, conducting wire between buccal mucosa and muscle *d*, wire suture completely encircling muscle on both sides of cleft

All sutures, including the wire, are removed in from 10 to 14 days, when it will be found that most of the horsehair sutures have already fallen out spontaneously

The details of some of the more important operative steps are depicted in Figures 746–752.

Repair of Clefts Involving Both Soft and Hard Palates (Uranostaphylorrhaphy)

Veau's Operation

For the repair of clefts involving both the soft and hard palate Veau's (87) operation is the most logical, as it comes nearest to restoring full anatomic relationship of the malformed parts. Function is not thereby materially interfered with, as no muscles

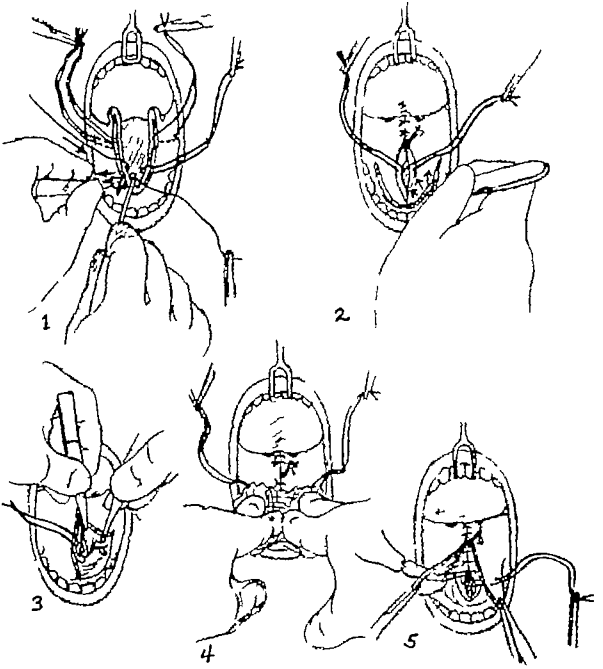


Fig. 753 Veau uranostaphylorrhaphy with palatal flaps. *1* wire suture passed on right side, silk loop on left side. Borders of cleft separated into buccal and nasal leaf (See Figures 742–743) Horse hair sutures passed through nasal mucosa to serve for approximation of nasal mucosa and buccal flaps. *2*, muscle suture completed Margins of soft palate approximated. Palatal flaps outlined by incision. *3*, flaps separated from palate from before backward. Posterior palatine artery lengthened by traction with blunt hook behind pedicle. *4* hemorrhage controlled by compression of flaps against hard palate. *5* sutures previously passed through nasal mucosa crossed and conducted through palatal flaps.

are cut; downward displacement of the velum, with its dead space above, is avoided, since the soft palate is not detached from the hard palate (as in the von Langenbeck operation); and cicatrization is reduced to a minimum, because the nasal as well as the oral surfaces of the flaps are covered with epithelium The underlying principles of the technic are: (1) a muscle suture, (2) separate approximation of the nasal and buccal mucosa, and (3) the formation of two rotation flaps deriving their blood supply from the great palatine artery (figs 753–754).

Denudation of Margins of Soft Palate Cleft and Passage of Wire Muscle Suture. The operation begins in the soft palate The Reverdin needle is introduced, the margins of the cleft are split, and the wire suture and silk loop are passed in exactly the same manner as in the repair of clefts limited to the soft palate (p 1147)

Denudation of Margins of Hard Palate Cleft The marginal incisions of the soft palate cleft are prolonged into the cleft of the hard palate and the layers separated. Since here the mucosa is firmly attached to the bone, its separation is tedious A Veau's

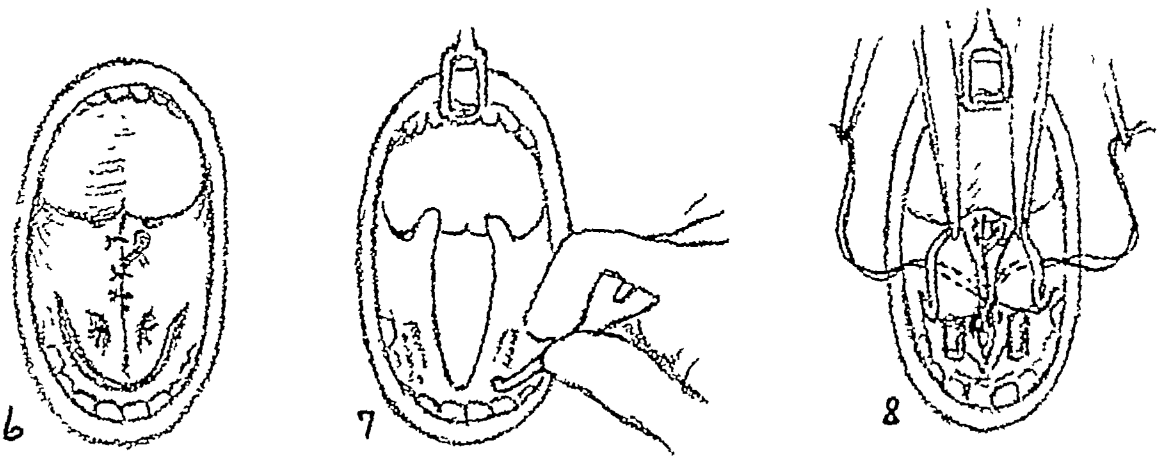


FIG 754 Veau uranostaphylorrhaphy with palatal flaps (cont) *6*, sutures tied, approximating buccal and nasal mucosa Palate packed with iodoform gauze dipped in collodion and left in place 7–10 days *7–8*, two-stage operation *7*, laminaria tents introduced beneath mucosal flaps, to facilitate their separation *8*, at end of 12 hours, thickened, loosened flaps raised, and operation continued as before (Récamier)

angulated elevator is engaged under the buccal mucosa close to the bone on the left side of the cleft As each 5 mm or so of the mucosa are raised, that part of the membrane is incised with a knife At the apex of the cleft, owing to the closer adherence of the mucosa and the greater depth and narrowness of the opening in this region, the dissection is more difficult, and great care must be taken to avoid perforation of the membrane The nasal mucosa is then elevated in a similar manner

Suturing of Nasal Mucosa. The margins of the nasal mucosa on the hard palate are now sutured from before backward by means of 4 horsehair sutures passed in such a manner that the ends will project on the buccal surface These sutures are left untied, to be used later in the anchoring of the palatal flaps They are passed in the following manner. A Reverdin needle, armed with horsehair, is passed through the mucous membrane on the right side. The suture is picked up in the cleft with forceps, threaded on a Trélat's needle, and conducted through the left side The two ends now appear in the oral cavity (fig 755). Four such sutures are passed at equidistant points The membrane on the nasal surface of the soft palate is then sutured, as already described on page 1148.

Suturing of Uvula and Completion of Wire Muscle Suture The segments of the uvula are approximated and the muscle suture completed (fig 745), as in the repair of clefts limited to the soft palate (p 1151)

Formation of Mucoperiosteal Flaps. Two mucoperiosteal flaps are now outlined on either side of the hard palate cleft, their pedicles lying posteriorly (fig 756-a) An incision is made in the midline of the palate, extending from the summit of the cleft to the dental arch From here it is continued around the alveolar border on either side lateral to the great palatine artery to points behind the alveolar processes of the superior

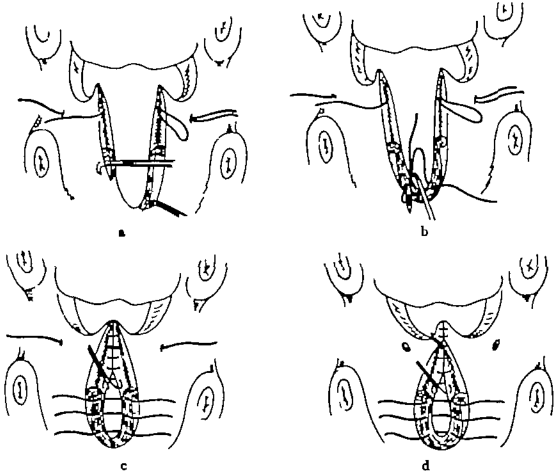


FIG 755 Details of Veau uranostaphylorrhaphy *a*, margins of cleft in soft palate split. Wire suture and silk loop passed. Mucoperiosteum separated from bone with Veau's angulated elevator *b* sutures passed for anchoring palatal flap. Reverdin needle threaded with horsehair passed through mucous membrane. Suture picked up in cleft with forceps, threaded on Trélat's needle, and conducted through opposite side. *c*, three of the 4 anchoring sutures passed, and balance of nasal mucosa approximated so that knots lie on nasal side. *d* segments of uvula approximated, and wire suture completed.

maxillae If teeth are present, the site for the incision is easily determined but in the absence of teeth the incision must be made at a safe distance medial to the tooth germs, lest the latter be injured. If the cleft does not extend as far forward as the anterior palatine foramen, the free ends of the flaps are cut in such a way that there will remain in front a strip of mucoperiosteum of sufficient width to hold the anterior anchoring sutures (55) With an angulated elevator the mucoperiosteal flaps thus outlined are raised from before backward. This manoeuver should be carried out as rapidly as possible, since the separation is associated with extensive hemorrhage.

When the flap has been raised to the level of the palatine foramen, the posterior palatine artery with its veins and nerves will be visible This bundle of vessels must be lengthened, if the flaps are to be shifted to the median line without tension The angulated elevator is placed behind the bundle at a point between its exit from the foramen and its entry into the flap, and mild but continuous traction is exerted (fig 756-b).

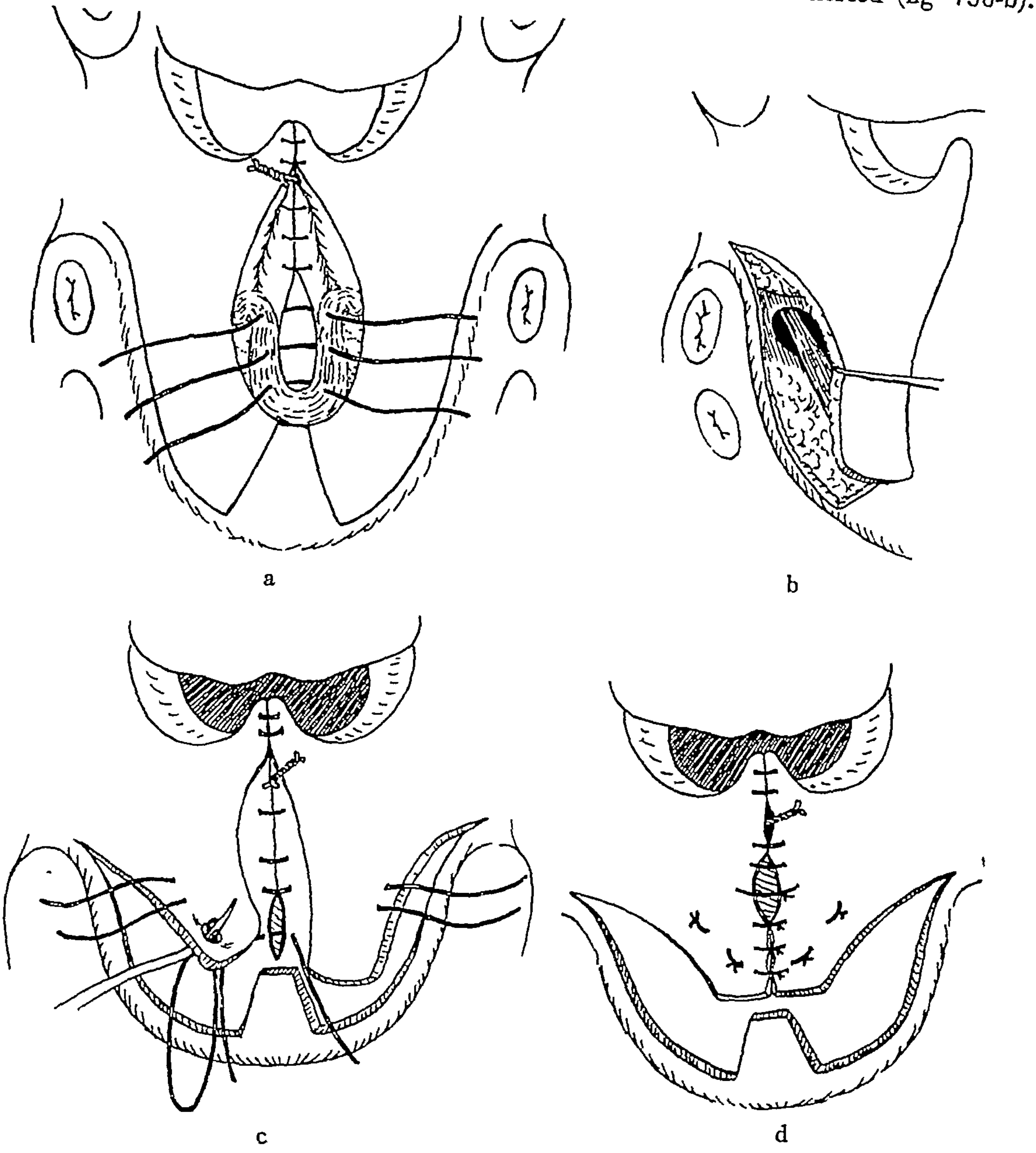


FIG 756 Details of Veau uranostaphylorrhaphy (cont) *a*, two mucoperiosteal flaps outlined *b*, flap raised from before backward Palatine vessels and nerves lengthened by gradual traction *c*, flaps rotated medially and fixed in place by sutures previously passed through nasal mucous membrane *d*, medial margins of flaps united.

This divides the strands of fibrous tissue which fix the bundle of vessels to the bone and permits of their emergence for a considerable distance from the canal The bundle can be further elongated, if necessary, by being gently separated from the under surface of the flap Hemorrhage is controlled by pressure of the flaps against the bone

Fixation of Flaps. When both flaps have been mobilized, they are shifted toward the

midline to complete the closure of the bony cleft and are fixed in their proper position by means of the 4 sutures previously passed through the nasal mucosa (fig 756-c) The 2 ends of the most posterior of these stitches are passed by means of a Reverdin needle through the flap on the right side of the cleft, being placed high enough on the flap so that, when tied, the flap will be drawn posteriorly (fig 756-d) The ends of the next succeeding suture are passed through the buccal flap on the left side in a like manner, the third suture through the right flap at a point anterior to the first, and the last suture similarly through the left flap Thus each flap has an anterior and a posterior suture, which, when tied, will bring into contact the nasal and buccal mucous membrane and obliterate the dead space between the palatal flaps and the bone (fig 757) All 4 sutures must be passed before they are tied, otherwise, the tying of the first pair will interfere with the placing of the others. Finally, the medial margins of the palatal flaps are united. Anteriorly this presents no difficulty, but posteriorly there will be some tension, the amount depending upon the degree to which the arterial pedicle was lengthened.

Following the operation, a tampon of iodoform gauze soaked in collodion is applied to the roof of the palate and kept in place for 10 days.

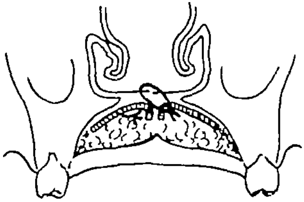


FIG. 757 Sectional view of Veau uranostaphylorrhaphy showing obliteration of dead space between palatal flap and bone

Von Langenbeck's Operation

The factors which determine the success of this operation are not so much the width and extent of the cleft as the height of the arch and the amount of available soft tissue on either side. The higher the arch the more easily can flaps be made to cover the opening, inasmuch as less lateral displacement will be required than in cases where the arch of the vault is lower (33)

The operation is based on the principle of an advancement flap The soft tissues of the vault are first freed by undermining If this does not provide sufficient mobilization to bring the flaps to the midline, lateral relaxation incisions are made, the hamular processes are fractured, and the palatal aponeurosis between the hard and soft palate is divided. The tissues are then shifted to the midline over the cleft and approximated.

While this procedure assures good anatomic closure it has, as previously stated, many objectionable features (1) It leaves a raw surface on the nasal side of the palate to undergo infection. (2) The cicatrization arising from the extensive undermining and lateral relaxation incisions leads to distortion of the alveolar borders, irregular denti-

tion, and a narrowing of the palate (3) The separation of the soft palate from the posterior border of the hard palate results in contraction, shortening, and rigidity of the velum and consequent interference with speech

Outlining of Mucoperiosteal Flaps. The first step of the operation consists in the outlining of a double-pedicled mucoperiosteal flap on the bony palate on either side of the cleft The incisions forming the lateral borders of the flaps are carried outside

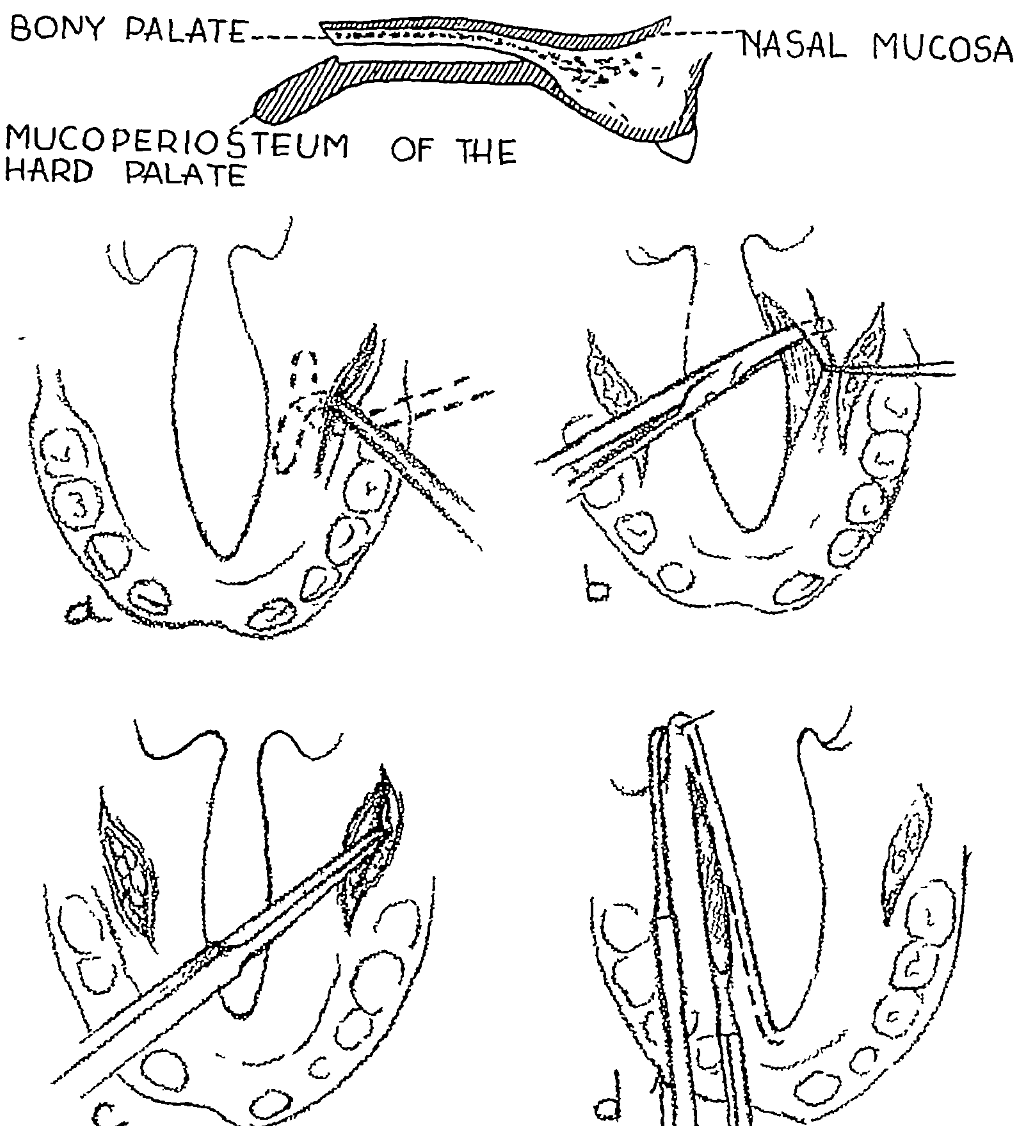


FIG 758 von Langenbeck uranostaphylorrhaphy *a*, mucoperiosteal flap raised *b*, palatal aponeurosis and nasal mucosa detached from posterior margin of hard palate Insert (above) shows plane of separation *c*, hamular process fractured *d*, left cleft margin pared while uvula is steadied with prod

of the palatine artery, close to and parallel with the alveolar arch, for a distance depending upon the amount of relaxation desired (fig 758-a) These incisions should be as short as is consistent with the primary aim of relief of tension (If a lateral incision on one side will serve the purpose, the one on the other side may be omitted) In Gothic palates where approximation of the flaps is easy, or in short narrow clefts it need not exceed 1 or 2 cm In the Norman type of palate, however, wherein approxima-

tion requires extensive shifting of the soft parts, or in cases where the cleft is long and wide it must necessarily be longer

The hamular process is palpated, and if the molar has erupted, the incision is begun just behind and 4 mm. medial to the gingival border In case the tooth has not yet appeared, it is begun at the junction of the palate with the most prominent part of the gum In either case it may be extended anteriorly as far as the lateral incisors if necessary, and posteriorly to a point midway between the posterior end of the alveolus

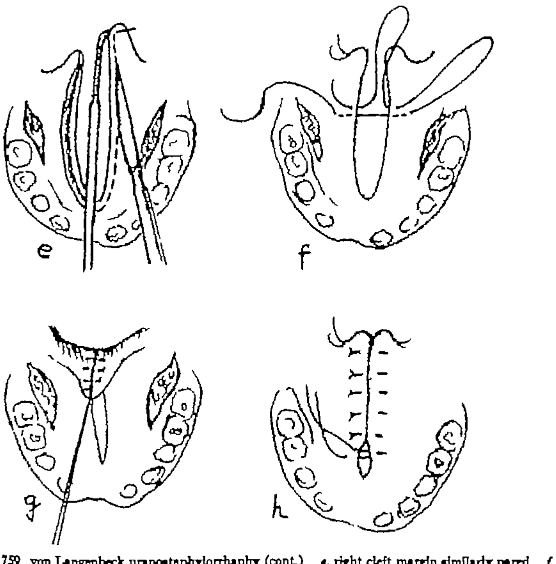


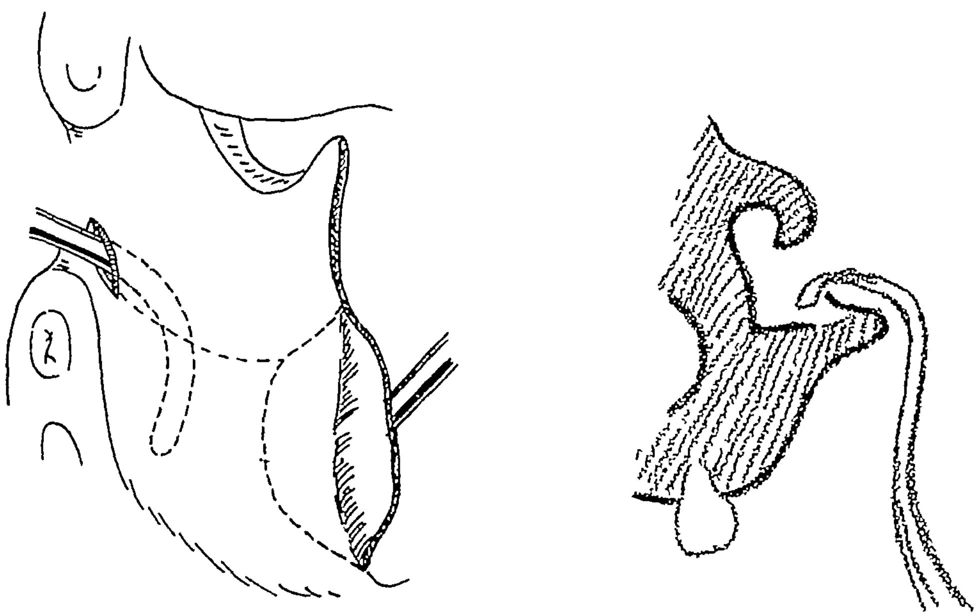
FIG. 759 von Langenbeck uranostaphylorrhaphy (cont.) *e*, right cleft margin similarly pared. *f* pared margins of soft palate approximated with on-end mattress-sutures *g*, uvula everted with traction suture, and nasal mucosa united. *h*, mucoperiosteal flaps approximated. For details, see text. (Blair)

and the posterior margin of the soft palate Care must be taken to leave in front a pedicle sufficiently wide to insure the nutrition of the flap

Elevation of Flaps. The flap is freed by means of a curved elevator inserted into the incision in the plane beneath the periosteum, so that the artery and nerve can be raised with the flap (fig 758-a) The instrument is worked backward, forward, and inward, until the tissues are separated up to the margin of the cleft. Bleeding is controlled by digital pressure Posteriorly the division is carried to the posterior margin of the palate. During the process of elevation every care must be taken to

avoid traumatization or buttonholing of the flap The greatest difficulty in the separation will be encountered at the anterior end of the bony cleft where the use of a variety of angulated elevators will be required

Division of Nasal Mucosa and Palatal Aponeurosis The nasal mucosa and palatal aponeurosis are detached from the posterior margin of the hard palate as follows (fig 758-b): One blade of a pair of blunt-pointed scissors curved on the flat is inserted between the periosteum and the bone, and the other blade is introduced into the nasopharynx above the soft palate The scissors are closed and the structures are thereby divided close to the bony palate in a plane directed upward and backward During this procedure care should be taken to preserve the continuity of the mucosa on the anterior aspect of the palate A gauze pack is introduced into the lateral incision, and the opposite side of the cleft is then similarly treated The soft palate and mucoperiosteal flaps thus freed will now hang loosely from the roof of the mouth



a b

FIG 760 Separation of mucoperiosteum, to obtain increased width of flap *a*, mucoperiosteum separated on nasal aspect with swan neck elevator and turned down *b*, sectional view (Lexer)

If it is found that the lateral incisions do not furnish sufficient relaxation, the hamular processes are exposed and fractured inward with a dull instrument (fig 758-c), the operator's finger being used as a guide (The use of a sharp instrument is to be eschewed, as it may sever the tendon of the tensor palati) Sectioning of these processes releases the tension produced by the tensor palati muscle and allows medial displacement of the palatal insertion of the superior constrictor of the pharynx If in spite of these efforts to obtain relaxation the flaps cannot be approximated without undue tension, the lateral incisions are packed and the operation completed one week later, at which time the flaps will have become thickened and the blood supply improved (6), so that longer relaxation incisions may be made without danger of necrosis of the flap Or, a part of the cleft may be closed, and the balance approximated at a later date (87)

Paring of Cleft Margins. With one side of the cleft uvula held on stretch by means

of a prod passed through its tip, a strip of tissue 1 to 2 mm. wide is excised in one piece from the margin of the cleft with a sharp thin bladed knife (fig 758-d) To facilitate the paring, the prod is shifted forward as the knife proceeds to the summit of the opening In order that the largest possible extent of raw surface may be obtained for approximation, the knife is held obliquely, so that more tissue is removed from the buccal than from the nasal aspect of the cleft. The opposite cleft margin is pared in a similar manner

Lexer (56) separates the mucoperiosteum on the nasal aspect of the hard palate through an incision made at a distance of 1 or 2 mm. from the margin of the cleft using a specially constructed swan neck elevator, and states that by this procedure he gains 1 cm of material (fig 760)

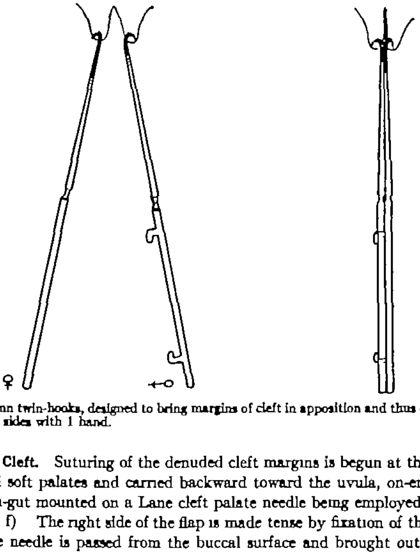


FIG. 761 Penn twin-hooks, designed to bring margins of cleft in apposition and thus enable operator to control both sides with 1 hand.

Closure of Cleft. Suturing of the denuded cleft margins is begun at the junction of the hard and soft palates and carried backward toward the uvula, on-end sutures of fine silkworm-gut mounted on a Lane cleft palate needle being employed for the purpose (fig 759 f) The right side of the flap is made tense by fixation of the uvula with a prod. The needle is passed from the buccal surface and brought out in the cleft, where it is released. It is again picked up with the holder and while the tip of the left half of the uvula is fixed as before the needle is passed from above downward (from the nasal to the buccal surface) As each suture is introduced, its ends are grasped with a forceps and used as a retractor to assist in the passing of the next suture. Penn (67) has devised a useful adjunct for suturing It consists of twin hooks which bring the edges of the cleft in correct apposition thus enabling the operator to control both sides with one hand. Figure 761 is self-explanatory A silk suture is now passed

through the tip of the uvula and used as a tractor to expose its nasal surface for approximation (fig 759-g) After the soft palate has been sutured, the mucoperiosteal flaps are approximated from behind forward (fig 759-h) The stitches are removed in 10 to 14 days

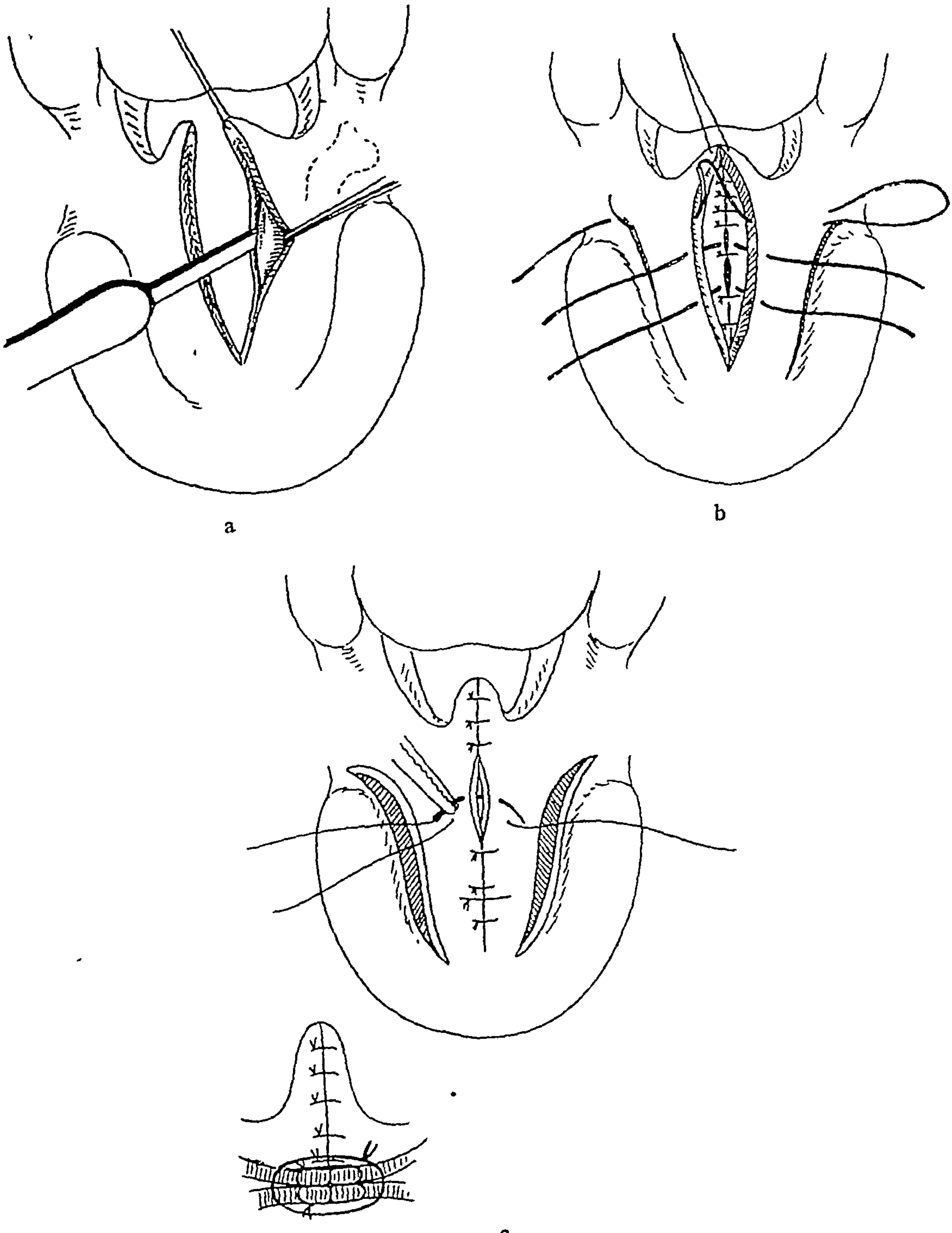
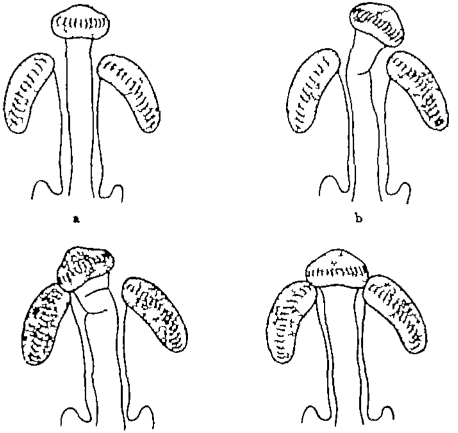


Fig 762 Closure of cleft in layers *a*, buccal and nasal mucoperiosteum separated from cleft *b*, relaxation incisions made Wire suture passed around palatal muscles, but not tied Nasal mucosa approximated Sutures passed through nasal and palatal mucosa, to bring membranes together and eliminate dead spaces *c*, buccal mucosa sutured Insert shows sectional view of nasal and buccal mucosa after sutures are tied (Kirschner)

Kirschner (48) separates the nasal and buccal mucous membranes and sutures them in separate layers, and to eliminate the intervening dead space he holds them in apposition by means of 1 or 2 through-and-through sutures (fig 762)

ALVEOLAR CLEFTS

The main problem in the repair of alveolar clefts is the protruding premaxilla. Early surgeons, in an effort to secure tensionless closure, removed the projecting bone, but this sacrifice of foundation caused a marked flattening and recession of the lip



a b

c d

Fig 763 Drachter's forcible repositioning of projecting premaxilla. *a* projecting premaxilla. *b*, nick made in neck of premaxilla on side of wider cleft, and bone rotated on its vertical axis toward maxilla. Corresponding lip repaired *c*, at second stage, process repeated on opposite side, and remaining cleft closed. *d* final position of premaxilla.

the so-called "harelip profile a deformity more unsightly and far more difficult to correct than the original condition. As a result this procedure was abandoned, and means were sought to effect a reduction of the bone without sacrifice of its substance (16, 24 26 49, 82) The first of these procedures consisted in forcible repositioning by finger pressure, an example of which is that of Drachter who made a nick in one side of the neck of the premaxilla, forced the bone into contact with the alveolus, and repaired the corresponding side of the lip At a second stage he repeated the process on the opposite side (fig 763) While such procedures made possible tensionless closure of the lip, and the immediate results were good these benefits were not maintained since the associated trauma injured the tooth buds the tilting backward of the frag

ment on an upward hinge caused the teeth to erupt lingually, and the traction exerted on the nose by the backward displacement of the septum gave rise to a depressed, flattened ala and a retracted columella Accordingly, this method was likewise abandoned in favor of gradual reduction, obtained by the suturing of the divided lip over the premaxilla, and this is at present the accepted procedure in the case of infants under 3 months of age The continuous pressure of the repaired orbicularis oris muscle effects a reduction of the displaced bone without injury to the tooth buds and with a minimum of subsequent deformity (8, 20, 35, 73, 81, 87) (fig 764) In older children, however,

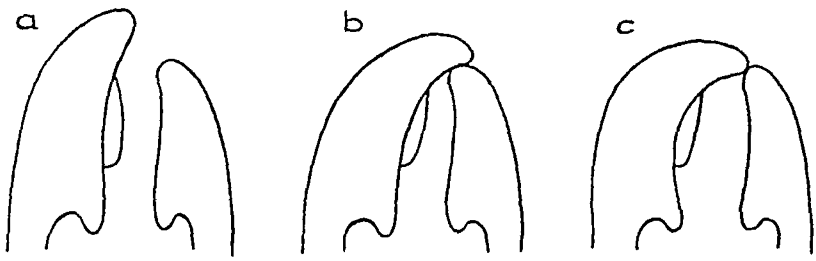


FIG 764 Contrasted effect of gradual and rapid reduction of premaxilla *a*, unilateral alveolar cleft *b*, gradual reduction by continuous pressure of repaired orbicularis oris muscle, resulting in maximal prominence of lip and diminution in width of cleft *c*, rapid forcible reduction, resulting in retraction of lip and increased width of cleft (Shoemaker)

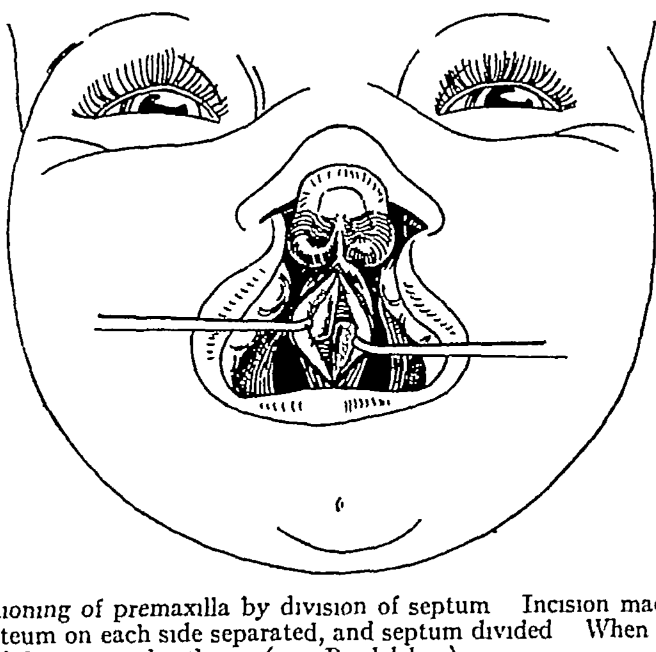


FIG 765 Repositioning of premaxilla by division of septum Incision made along free border of vomer Mucoperiosteum on each side separated, and septum divided When maxilla is repositioned, septal margins will glide over each other (von Bardeleben)

the bone is not sufficiently plastic to permit of such reduction, and forcible repositioning must be resorted to To effect this with the least possible damage, various operations on the vomer with a view to creating room for the backward displacement of the bone have been suggested (9, 23, 54, 62, 74) Von Bardeleben advocated a division of the septum, so that when the premaxilla was displaced backward, the septal margins would glide over each other without buckling (fig 765) An incision about 1 cm in length was made along the free border of the vomer behind the premaxilla Through this opening the mucoperiosteum on both sides was raised throughout its entire extent, and with a pair of scissors the septum was sectioned as high up as possible This

procedure has since undergone many modifications, but it still remains the basis of the operation in use today Pichler (69, 70), in order to prevent undue distortion of the septum, divides the vomer 2 cm behind the premaxilla (fig 766) Veau (87), to avoid a lingual eruption of the teeth from a backward tilting of the bone, detaches the premaxilla at its narrow neck, slides it back on the septum on the same plane as "one would close a drawer," and fixes it to the freshened margins of the maxilla (fig 767) To overcome the nasal deformity occasioned by the backward displacement and to

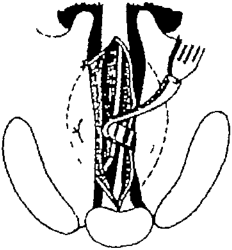


FIG 766 Repositioning of premaxilla by division of septum Vomer divided 2 cm. behind premaxilla. Septal mucosa raised on both sides and turned under palatal mucoperiosteum Elevator shown separating mucoperiosteum (Pichler)

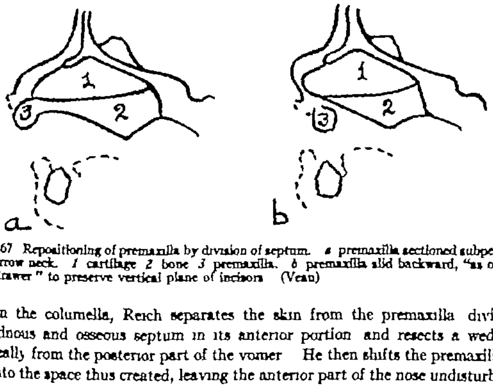
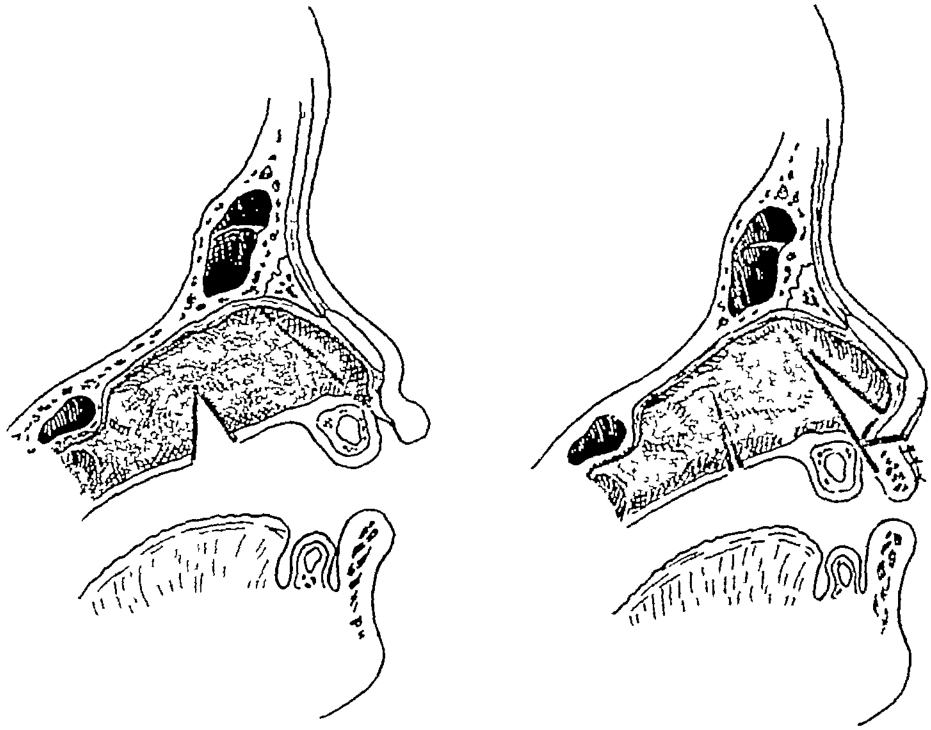


FIG 767 Repositioning of premaxilla by division of septum. *a* premaxilla sectioned subperiosteally at its narrow neck. *1* cartilage *2* bone *3* premaxilla. *b* premaxilla slid backward, "as one would close a drawer" to preserve vertical plane of incisors (Veau)

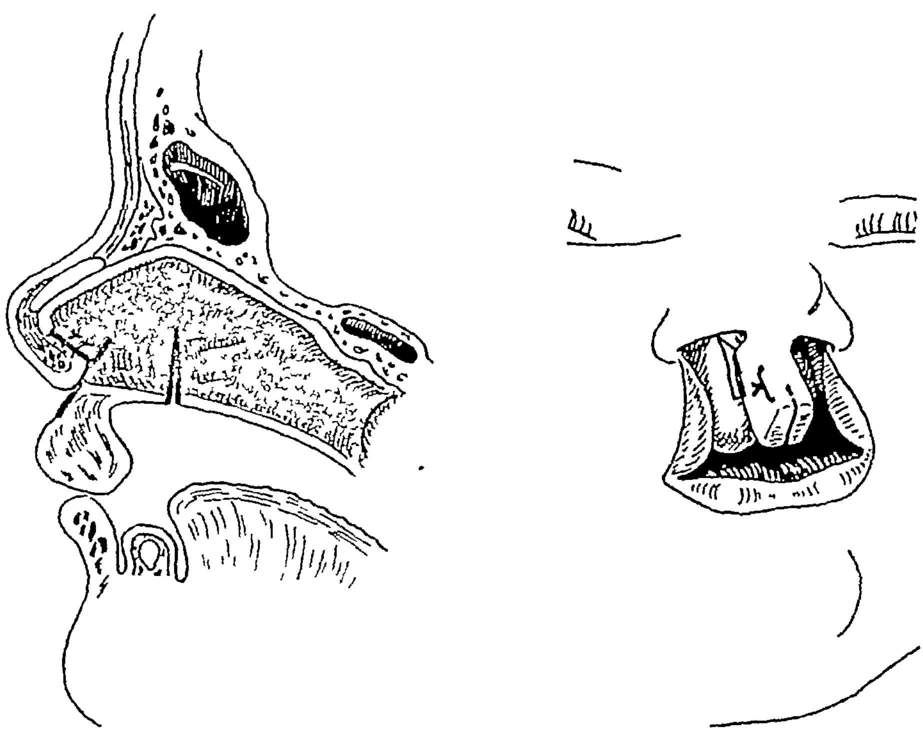
lengthen the columella, Reich separates the skin from the premaxilla divides the cartilaginous and osseous septum in its anterior portion and resects a wedge subperiosteally from the posterior part of the vomer He then shifts the premaxilla backward into the space thus created, leaving the anterior part of the nose undisturbed and uses the previously detached skin to lengthen the columella (figs. 768–769)

In the case of unilateral clefts, before repositioning is undertaken, the premaxilla must be separated from the alveolus on the uncleft side. The incision should be so planned that the bone will fit easily into the opening in the alveolar arch and carry



a b

FIG 768 Repositioning of premaxilla by division of septum. *a*, skin separated from premaxilla Septum divided in anterior portion Subperiosteal triangle resected from posterior part of vomer *b*, premaxilla shifted backward into space created Anterior septal wall supporting nose left undisturbed Previously detached skin used to lengthen columella (Reich)



a b

FIG 769 Repositioning of premaxilla by division of septum *a*, skin of premaxilla elevated Wedge removed from vomer Premaxilla set back Detached skin used to lengthen septum *b*, terminal end of philtrum divided, to assist in reconstruction of nasal floor (Matti)

the septum to the median line. The alveolus is approached through a mucosal incision made along its lower margin just posterior to the canine tooth The bone is divided with a fine chisel or knife between the germs of the lateral incisor and canine, or between the canine and first molar (fig 770) The mucous membrane on the margins of the alveolar defect is then pared, and by digital pressure the premaxilla is rotated on its vertical axis into the median line Immobilization of the bone is obtained either by a proper closure of the lip over it, or by a suture passed through the bone segments (48, 92)

The repair of the lip in cases of alveolar clefts presents an additional problem The skin of the premaxilla belongs partly to the columella and partly to the lip If it is wholly incorporated in the lip repair there will result a shortening of the columella with a consequent drag of the nasal tip Therefore, if such a secondary deformity

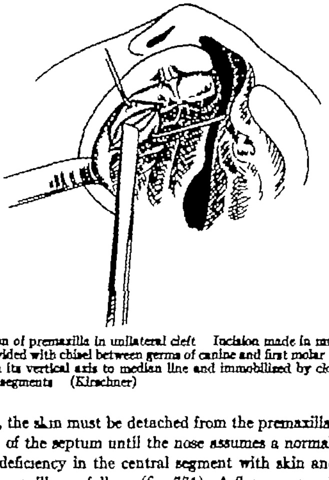


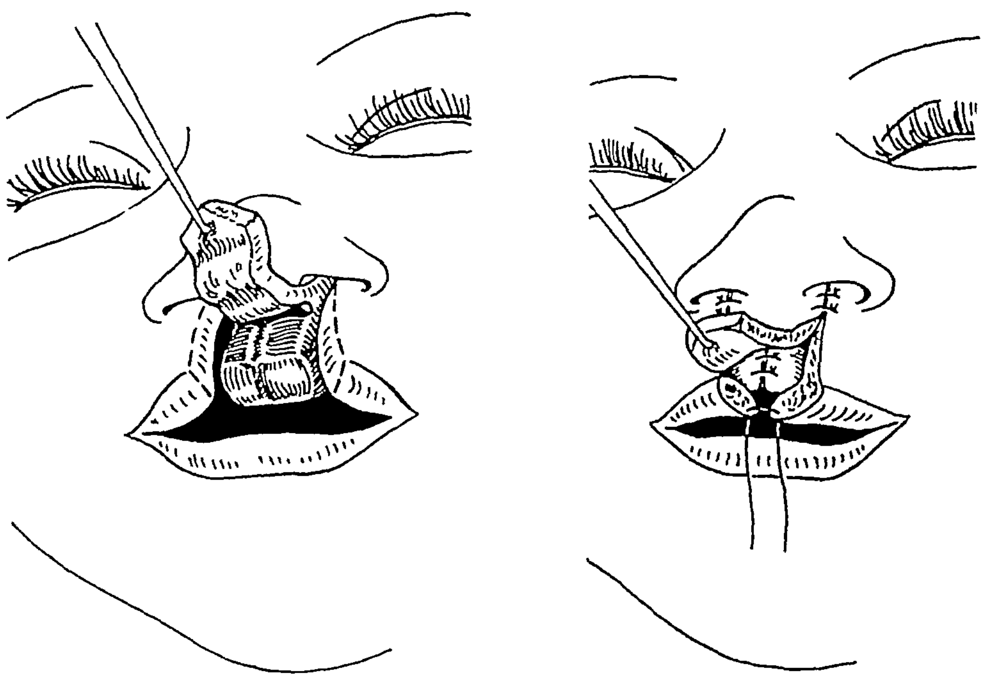
Fig. 770 Reduction of premaxilla in unilateral cleft Incision made in mucosa along lower border of alveolus. Bone divided with chisel between germs of canine and first molar Margins of cleft pared. Premaxilla rotated on its vertical axis to median line and immobilized by closure of lip or by suture passed through bone segments (Kirschner)

is to be prevented, the skin must be detached from the premaxilla and advanced along the caudal margin of the septum until the nose assumes a normal projection Meyer (61) replaces the deficiency in the central segment with skin and mucous membrane taken from the premaxilla, as follows (fig 771) A flap composed of skin and mucosa is elevated from the premaxilla Two small mucosal flaps are then raised from the margins of the cleft, turned hinge fashion, so that their mucosal surfaces face the oral cavity, and are sutured together in the midline. The vermilion borders are then trimmed obliquely and united at their lowermost points by means of a suture The margins of the previously raised premaxillary flap are sutured to the pared margins of the cleft, and the tip of the flap is fitted into the V-shaped defect in the vermilion to form a prolabial tubercle. Mattu likewise uses the skin of the premaxilla to lengthen the columella. Figure 769 is self-explanatory Lexer (56) repairs the lip after the manner of Mirault and reconstructs the vermilion border of the central portion by

means of a mucosal flap taken from the lower lip The procedure is illustrated on page 1071

Optimal Time for Operation

In alveolar clefts complicated with clefts of the lip and palate and in which the premaxilla protrudes markedly, the need for early reconstruction is imperative The repair should be carried out as soon after the birth of the infant as his general health will permit—i e , as soon as he regains his birth weight, usually between the eighth and the fourteenth day If correction is delayed beyond the third month, the bones can no longer be molded by pressure of the reconstructed lip muscle, and repositioning of the premaxilla and restoration of the alveolar arch can then be accomplished only



a b

Fig 771 Repair of bilateral cleft associated with deficient development of philtrum *a*, flap of skin and mucosa elevated from premaxilla Dotted lines show incisions for two mucosal flaps, to be turned in as lining *b*, mucosal flaps sutured together Vermilion border pared obliquely, and lowermost points approximated with sutures Premaxillary flap sutured to margins of cleft (Meyer)

by force, with its consequent interference with the future development of the jaw, disturbance in the eruption of the teeth, and nasal disfigurement

It is generally agreed that in these complicated clefts closure of the entire defect at one time is too formidable an operation, considering the age of the patient There is a difference of opinion, however, as to the proper sequence of the procedures Some surgeons repair the palate in the first stage and leave the lip for a later date, on the grounds that the labial cleft affords a better exposure for manipulation of the palate The majority reverse the order, and correct the lip first They point out that closure of the cleft lip, with a proper reconstruction of the orbicularis oris muscle and floor of the nose, is of decided benefit in directing the deformed parts toward a more normal position, thus simplifying the secondary operation and making its success more certain

If the cleft is unilateral, probably the best plan is to close the cleft lip and the anterior

part of the palate in the first operation and the balance of the cleft at a later date, between the patient's first and second year Bilateral clefts are best repaired in 3 or more stages. In the first one side of the lip and the corresponding anterior part of the palate are approximated, the bilateral cleft being thus converted into a unilateral one In the second stage, 4 to 5 weeks later, the other side is similarly repaired, and in the third, the opening remaining in the posterior part of the palate is closed.

Veau's Operation

Veau's operation for the repair of bilateral alveolar clefts is here detailed To avoid unnecessary repetition the steps of repair of unilateral alveolar clefts are merely depicted diagrammatically (figs 780–782) since the technical details of the latter procedure differ in no essential from the second stage of the bilateral variety

The procedure is carried out in 3 or more stages. The first operation is performed when the infant is 6 to 8 weeks old, and consists in the repair of the lip on one side of the widest cleft together with the floor of the nose and the anterior part of the palate on the corresponding side, the bilateral cleft being thus converted into a unilateral one. Following this stage, the cleft on the other side tends to become larger, due to the contraction of the scar tissue on the operated side The second stage is carried out 2 or 3 months later, at which time the lip, nasal floor, and anterior part of the palate on the opposite side are repaired in a similar manner At the end of this stage the remainder of the opening will be a little more difficult to obliterate as the anterior closure has a tendency to spread the posterior part of the cleft. The third operation is performed when the child is 18 months to 2 years of age and consists in the closure of the balance of the palate cleft.

The technic described follows closely that of Récamier (71 72) at the Hôpital Saint-Michel, whose work the writer has had an opportunity to observe

First Stage. *External Incision* A mucocutaneous triangle is removed from the left margin of the cleft in precisely the same manner as in simple unilateral cleft lip (fig 772-(1)) An incision is then made, beginning in the lower anterior margin of the vomer and continued around the premaxilla along its mucocutaneous junction. Just before the midline is reached, the knife is turned at right angles into the mucosa and is directed horizontally along a somewhat lower level to a point just beyond the mid line, where it is curved backward to end the cut at the gingival groove in the midline (fig 772 (2)) In a later stage of the operation this incision will be continued around the bone to the starting point.

Elevation of Vomerine Flap An incision is now made, beginning 1 cm in front of the uvula and carried forward between the white mucosa of the mouth and the red mucosa of the nose to join the starting point of the external incision (fig 772-(3)) Through this incision a flap of vomerine mucosa is bluntly dissected up (fig 772 (4)) The separation should be carried well up on the septum, to permit of tensionless closure. The dissection offers no difficulty except in the vicinity of the premaxilla, where the membrane is firmly attached Here care must be taken to avoid perforation of the nasal cartilage Hemorrhage is slight and can be controlled by pressure

Elevation of Palatine Flap An incision is now made in the palate, beginning posteriorly and passing parallel to and just inside the alveolar arch to the anterior extremity of the alveolus, around which it curves to become continuous with the

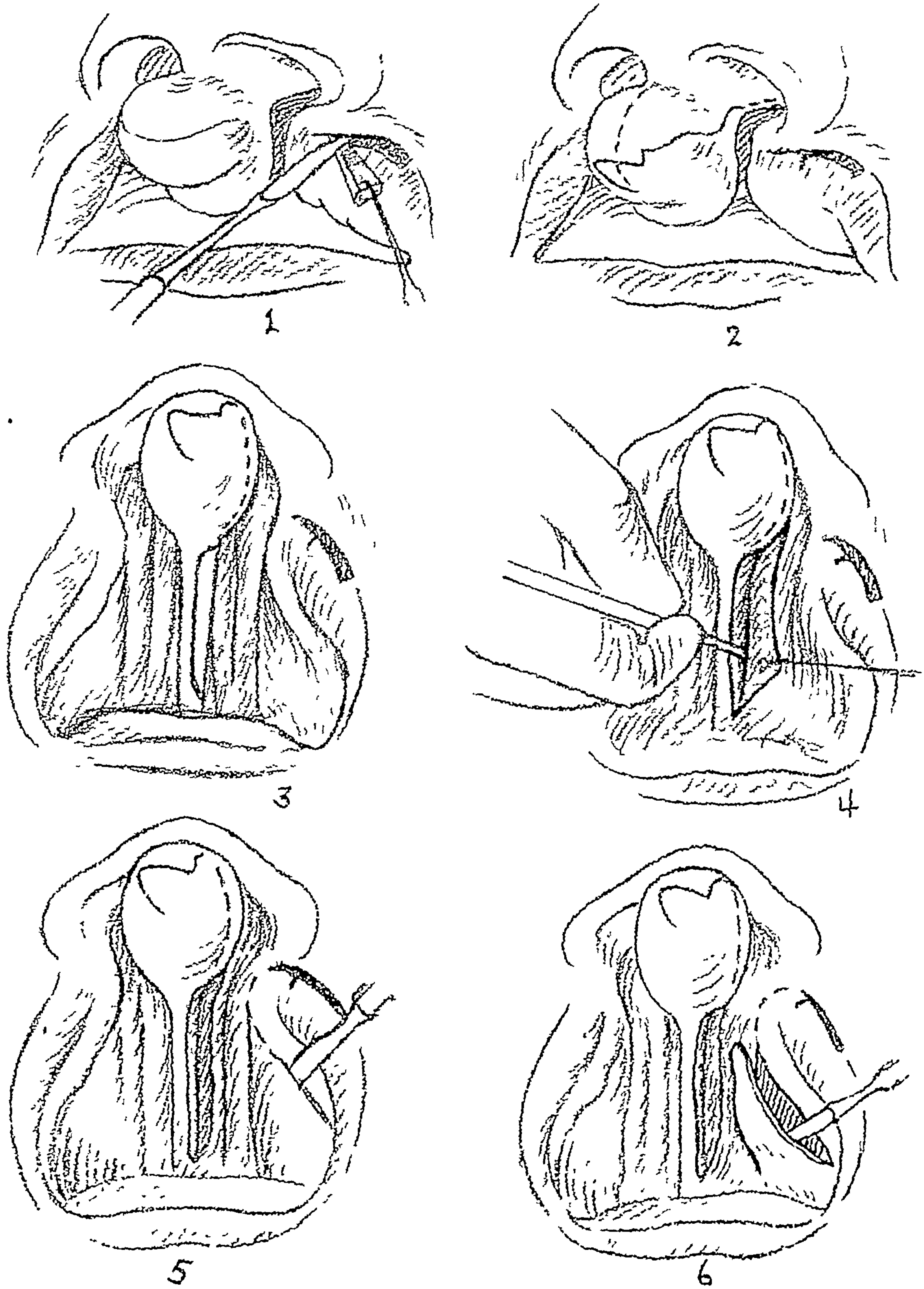


Fig 772 Veau operation for bilateral alveolar cleft *First Stage* *1*, mucocutaneous triangle removed *2*, incision made in premaxilla *3*, incision made for vomerine flap *4*, vomerine flap elevated *5*, incision made for palatal flap *6*, palatal flap elevated.

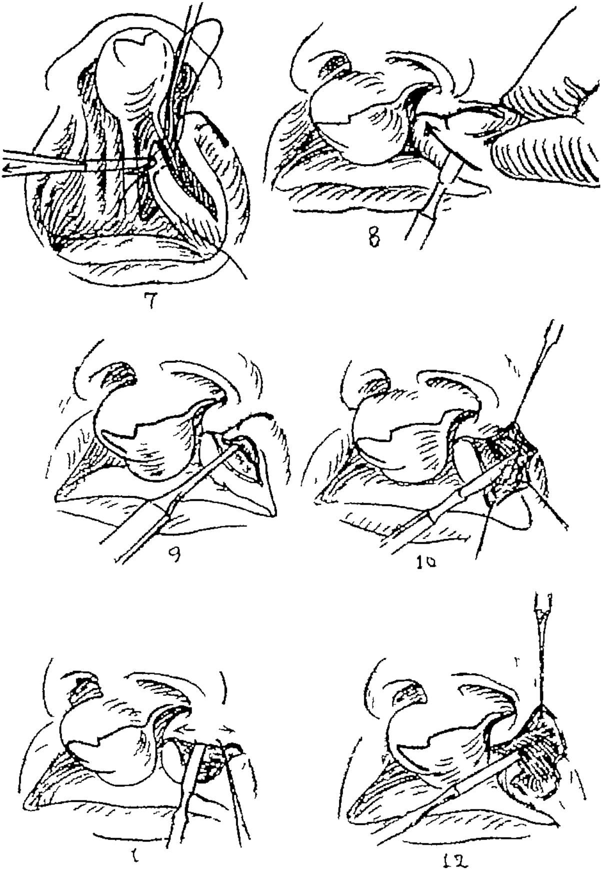


FIG. 773 Veau operation for bilateral alveolar cleft. *First Stage* (cont.) *7* vomerine and palatal flaps approximated. *8* incision made for mobilization of alar base. *9* alar base separated from premaxilla. *10* orbicularis oris exposed. *11* upper lip of incision undermined. *12* orbicularis oris elevated.

wound in the lip formed by the triangular excision (fig 772-(5)) Through this incision a mucoperiosteal flap, pedicled posteriorly, is raised from the hard palate in exactly the same manner as prescribed for the repair of a cleft palate (fig 772-(6))

Approximation of Vomerine and Palatine Flaps The palatine and vomerine flaps are approximated, raw surface to raw surface, and fixed by a single mattress-suture knotted on the buccal side (fig 773-(7)) This suture is passed in the following manner A threaded Reverdin needle is passed from the nasal surface through the vomerine and palatal flaps, to emerge on the buccal surface The thread is drawn out and the needle withdrawn The instrument is then threaded with the other end of the suture and passed in a similar manner at a few millimeters from the first The 2 extremities projecting from the palatal flap are tied

Mobilization of Alar Base With the lip everted between the thumb and forefinger, an incision is made along the gingivolabial sulcus and carried forward to join the incision previously made around the alveolar process just below the point where the ala joins the lip (fig 773-(8)) Through this incision the alar base is separated from the premaxilla to permit of its being shifted to the median line (fig 773-(9))

Exposure of Orbicularis Muscle The mucosa on the lateral side of the lip between the 2 previously made incisions is dissected up to expose the orbicularis muscle (fig 773-(10)) This manoeuver must be carried out with care, as the membrane in this locality is very fragile The fibers which are spread out over a wide area at the base of the nose are bared by undermining the upper lip of the wound (fig 773-(11)) When all the strands have been brought to view, they are gathered together in the form of a bundle (fig 773-(12))

Separation of Septal Mucosa Through the incision made in the premaxilla in the first step of the operation the septal mucosa is elevated (fig 774-(13)) As a rule, this can be done with a blunt separator, but occasionally the adhesions are so firm that a knife must be used, in which case great care is required to avoid perforation of the membrane The dissection is carried sufficiently high to assure relaxation of all tension

Separation of Alar Mucosa Through the anterior part of the alveolar incision a periosteal elevator is introduced, and a flap of mucosa is elevated from the lateral wall of the nose, the dissection being carried up high on the maxilla (fig 774-(14)) At a later step the flap of nasal mucosa thus liberated is sutured with catgut to the apposing vomerine flap to form the floor of the nose

Removal of Mucosa from Premaxilla After the liberation of the structures entering into the formation of the nasal floor, the lower lip of the premaxillary incision is undermined down to the gingival groove (fig 774-(15)), and the mucosal flap is excised (fig 774-(16))

Passage of Suture for Immobilization of Alar Base With the margin of the lateral alveolar incision elevated, a Reverdin needle is passed from within outward through the base of the ala, incorporating a bite of muscle, and is threaded with a suture and withdrawn (fig 774-(17)) The needle is unthreaded and passed subcutaneously from the opposite nostril, to emerge in the cleft (fig 774-(18)) It is then mounted with the ends of the suture previously passed through the base of the ala and withdrawn (fig 775-(19)) The ends are held temporarily with a clamp At a later step these sutures will be tied and will serve to relieve the tension on the stitches in the nasal floor and to maintain the normal position of the ala

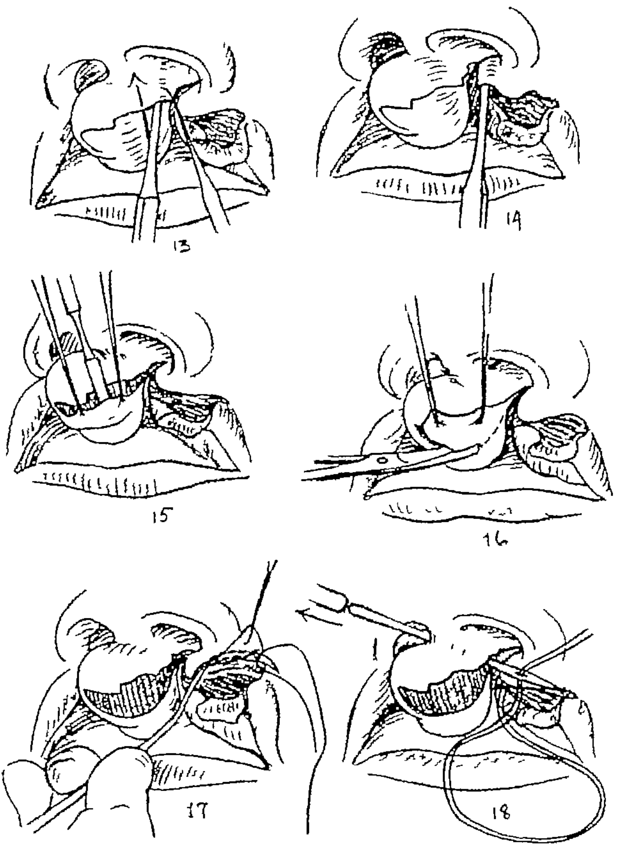


Fig 774. Veau operation for bilateral alveolar cleft. *First Stage* (cont.) *13* septal mucosa elevated. *14* alar mucosa separated *15* lower lip of incision undermined. *16* premaxillary mucosa excised. *17* suture passed to immobilize alar base. *18* suture engaged in needle, to be brought out through opposite nostril

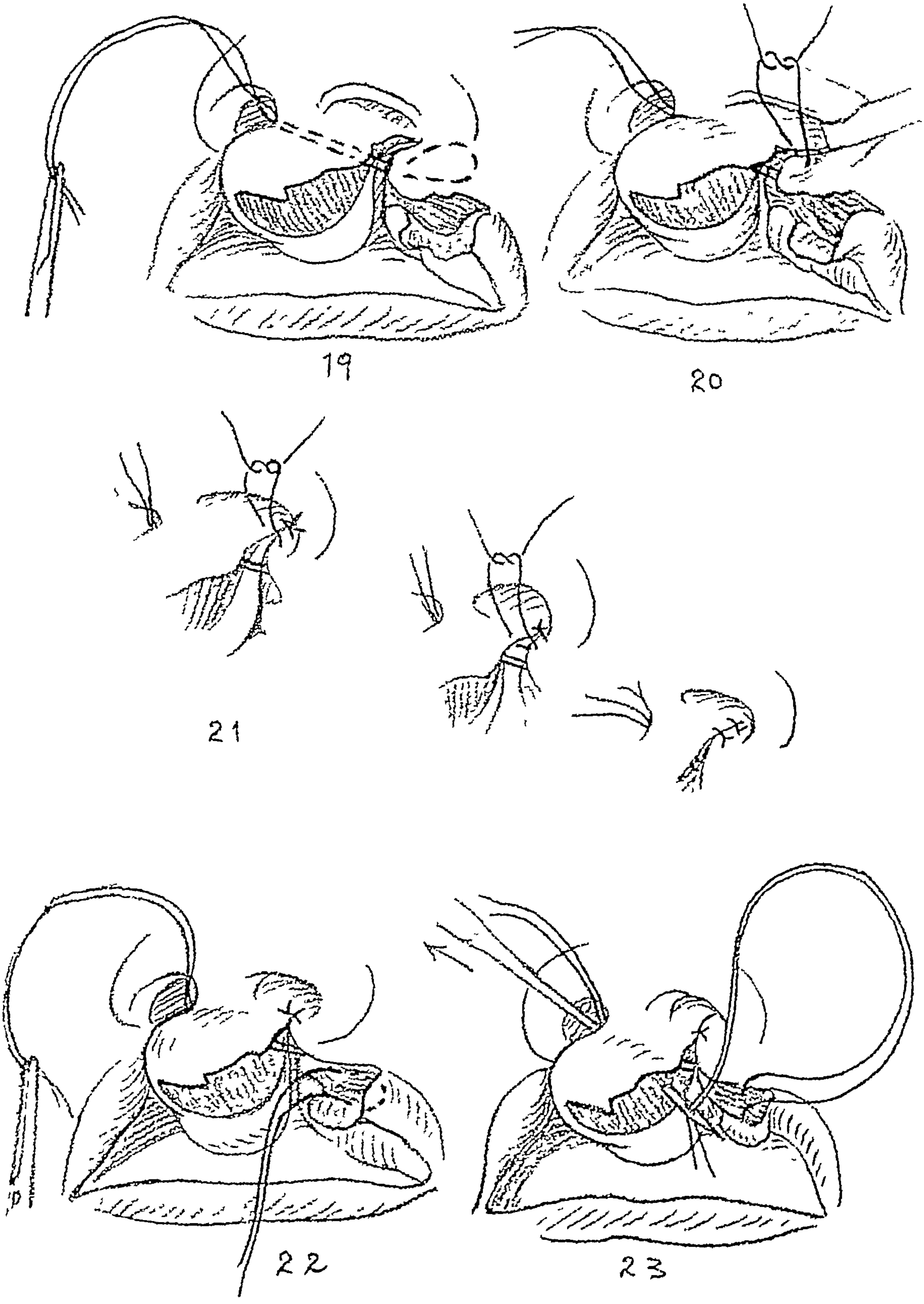


FIG 775 Veau operation for bilateral alveolar cleft. *First Stage* (cont) *19*, passage of suture for immobilization of alar base completed *20*, vomerine flap sutured to nasal mucosa *21*, method of passing sutures *22*, wire suture passed through orbicularis oris *23*, wire suture drawn out

Reconstruction of Floor of Nose The vomerine flap is sutured to the flap of mucosa previously raised from the lateral wall of the nose (fig 775-(20)) Suturing is begun posteriorly and carried forward, the stitches being passed obliquely, so that when they are tied, the ala will roll in and the alar base will attain the proper curvature (fig 775-(21))

Reconstruction of Orbicularis Oris Muscle Through the end of the orbicularis muscle a wire suture is passed with a Reverdin needle (fig 775 (22)) Obviously, the two halves of the muscle cannot be united until the second stage of the operation therefore, in order that the muscle may be secured in its normal location, a Reverdin needle is passed through the opposite nostril and made to take a subcutaneous course over the premaxilla into the cleft, where it is threaded with the ends of the wire and withdrawn, carrying the wire with it (fig 775-(23)) The extremities are temporarily held with a clamp and are tied at a later step

Approximation of Margins The first suture is passed at the junction of the nasal base and the lip (fig 776-(24)) The next is introduced through the end of the mucosal flap on the lateral side and united to the mucosa of the premaxilla in such a manner that when the ends are tied the flap will cover the denuded surface (fig 776-(25)) With this suture acting as a tractor the mucous membrane is brought together from behind forward (fig 776-(26)) The mucosal and cutaneous margins are approximated This must be done with care. The procedure will be facilitated by the passing of 2 sutures, the first serving to steady the part while the second is being tied (fig 776-(27)) After the tying of the second suture (fig 776-(28)) the mucosal flap is trimmed (fig 776-(29)) and the approximation of the mucosal margins completed (fig 777 (30)) Finally, the two sutures emerging from the nostril of the unoperated side are tied over pledgets of gauze (fig 777 (31))

Second Stage With but few exceptions the second operation is carried out in the same manner as the first. An elongated mucocutaneous triangle is excised from the lip as before (fig 777 (32)) An incision is made along the mucocutaneous junction of the premaxilla and continued intra-orally along the base of the vomer to end opposite the scar line of the first operation (fig 777 (33)) The vomerine and palatine flaps are raised and joined by a suture (fig 777 (34)) A section of mucosa is removed from the premaxilla, a lip of tissue being left just sufficient to hold the sutures (fig 777-(35)) Through the wound created by the triangular excision on the lip a flap of mucosa large enough to cover the denuded premaxilla accurately is turned down, and the muscle is exposed A suture is passed through the tissues beneath the base of the ala and withdrawn from the opposite nostril, as in the first operation (fig 778-(36)) The sutures joining the vomerine and the nasal mucosal flaps are passed from behind forward to the margin of the nostril (fig 778-(37)) The 2 halves of the orbicularis oris muscle are now united by means of a wire suture, as illustrated in Figure 778 (38) The wire sutures emerge on the mucous surface at points equidistant from the proposed suture line (fig 778-(39)) By means of these sutures the lip is everted (fig 778-(40)), and a stitch is placed between the flap previously raised on the lip and the mucosal margin of the premaxilla (fig 778-(41)) Two sutures are now passed exactly at the mucocutaneous junction (fig 779 (43)) The cutaneous and mucosal sutures above and below it are completed as in the first operation (fig 779 (44–46)) The suture passing out of the nostril is tied over a pledget of gauze (fig 779 (47))

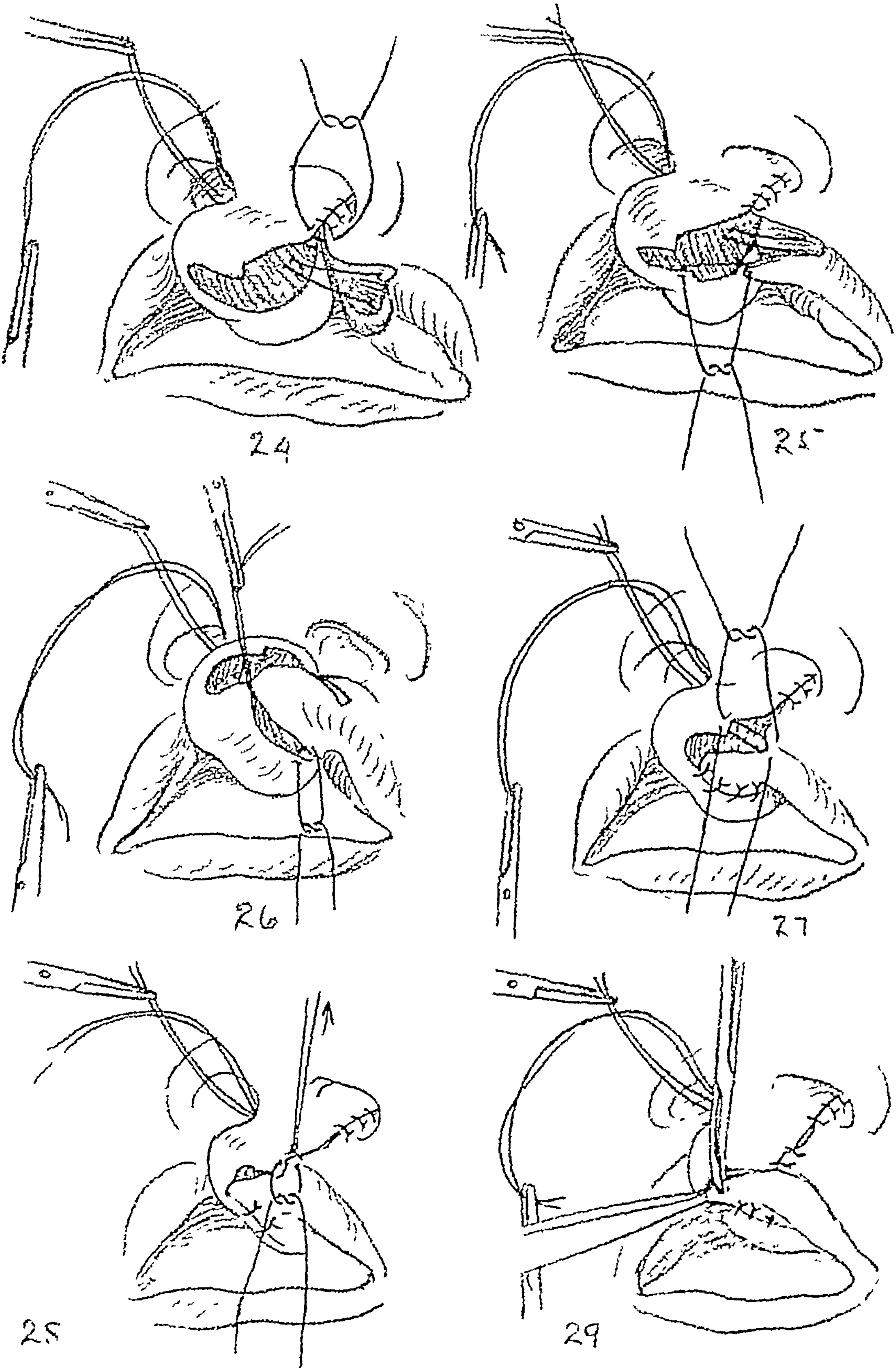


Fig. 776 Veau operation for bilateral alveolar cleft *First Stage* (cont) *24*, cutaneous margins approximated *25*, suturing continued *26*, with suture as tractor, mucosal margins united *27*, mucosal and cutaneous margins approximated with 2 sutures, one steadying part while other is tied *28*, second suture tied *29*, mucosal margin trimmed

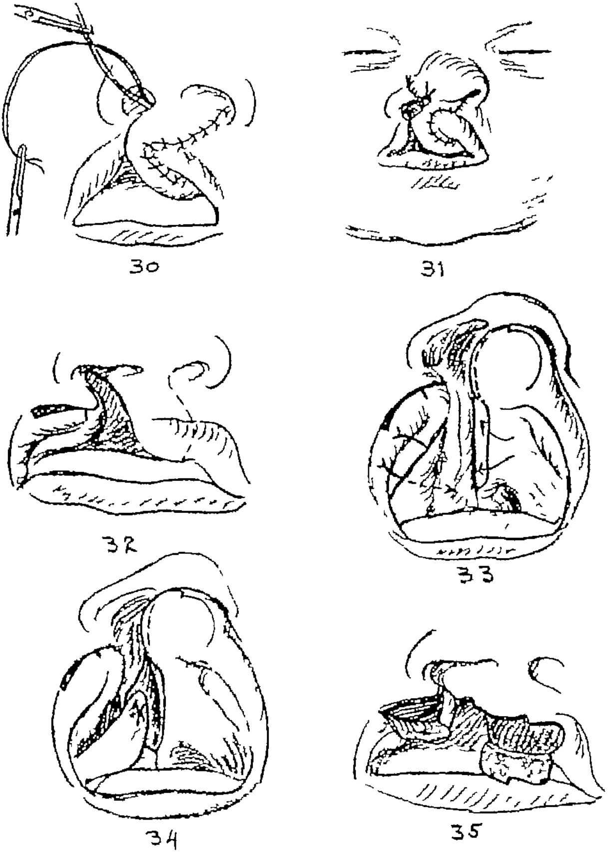


FIG. 777 Veau operation for bilateral alveolar cleft. *First Stage* (concl.) *30* approximation completed. *31* sutures for immobilization of alar base tied over gauze pledgets. *Second Stage* *32* mucocutaneous triangle excised. *33* incision outlined in premaxilla. *34* vomerine and palatal flaps united by suture. *35* mucosal strip removed from premaxilla.

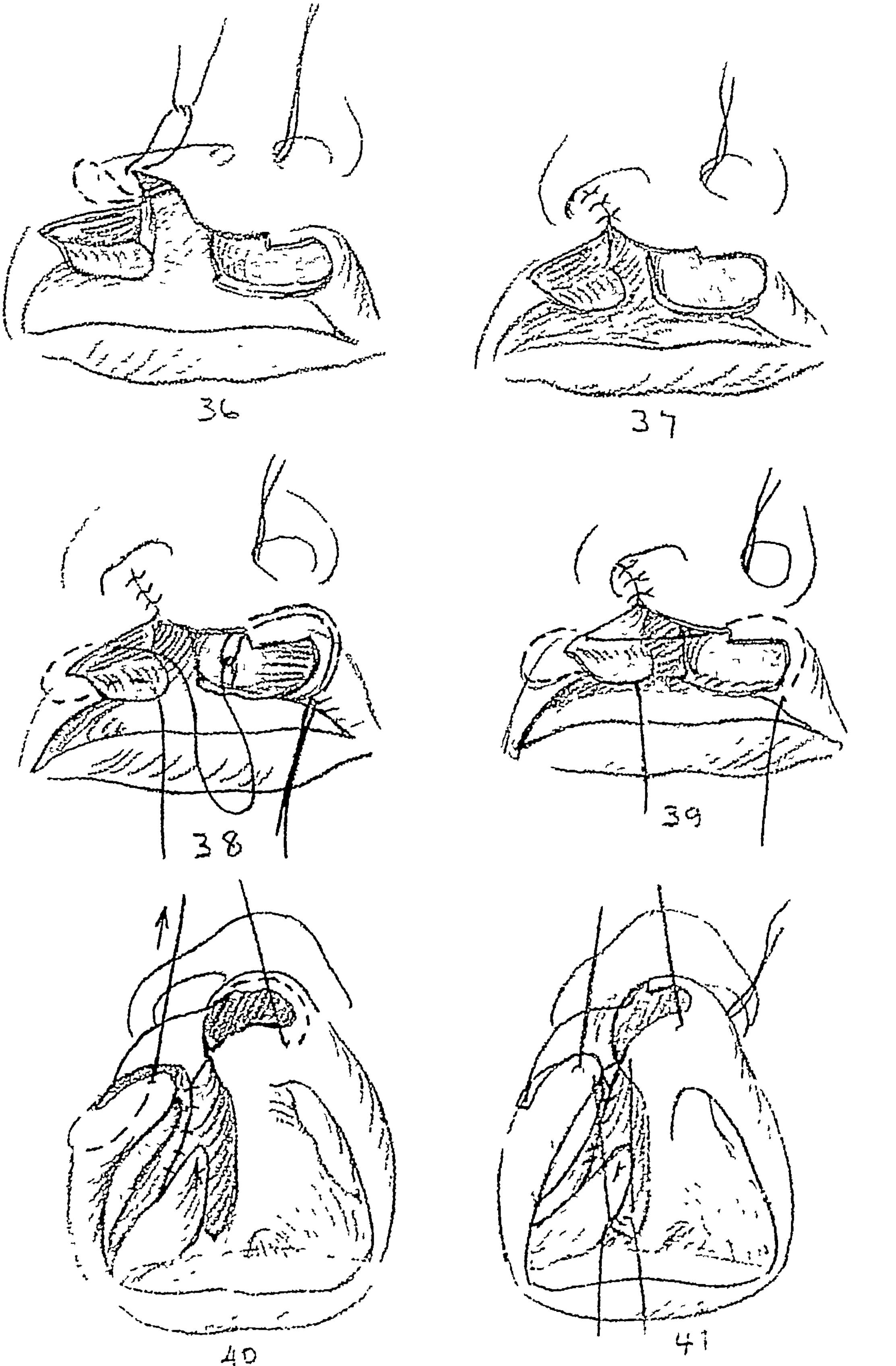


FIG 778 Veau operation for bilateral alveolar cleft *Second Stage* (cont.) *36*, flaps of mucosa turned down, to expose muscle Suture passed, to immobilize alar base to opposite nostril *37*, nasal and vomerine mucosa approximated *38*, wire suture passed, to approximate 2 halves of orbicularis oris *39*, wire suture completed *40*, lip everted with wire suture *41*, suture for approximation of mucosal margins passed

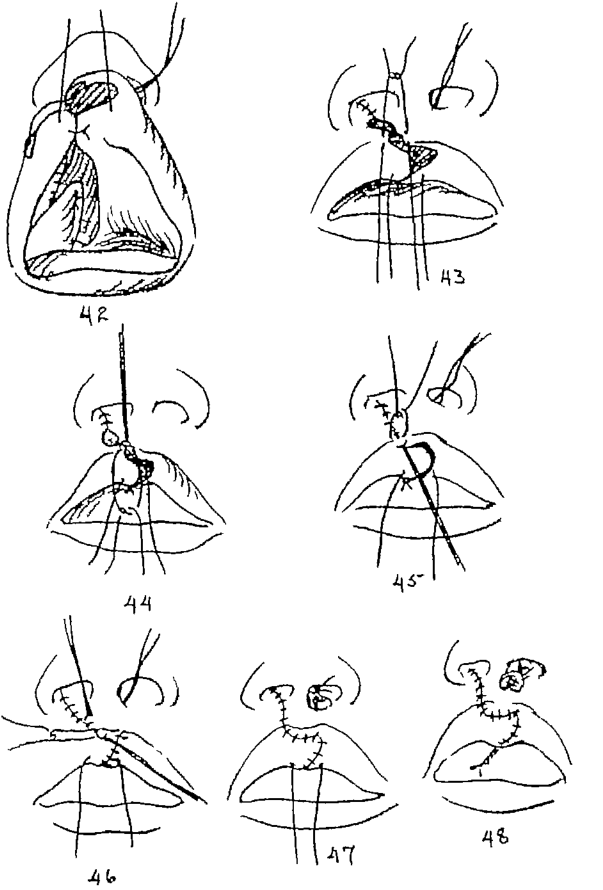


Fig. 779 Veau operation for bilateral alveolar cleft. *Second Stage* (concl.) *42* first suture tied. *43* suturing of mucosal and cutaneous margins continued. *44* suturing continued. *45*, suturing continued. *46* suturing completed. *47* suture to immobilize alar base tied over gauze pledget. *48* wire suture tightened and twisted. (Récamier)

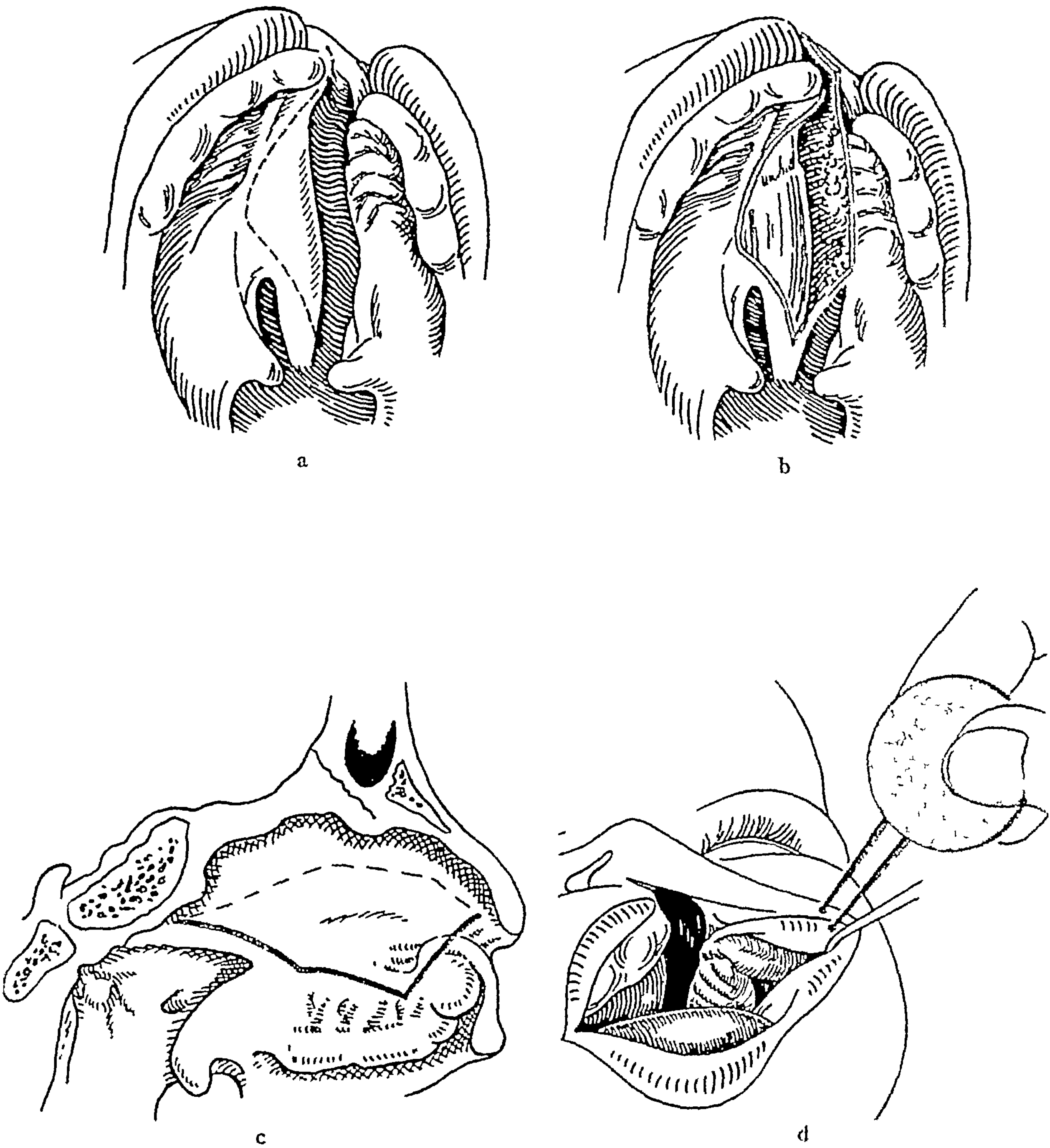


FIG 780 Veau operation for unilateral alveolar cleft *a*, vomerine flap outlined by dotted line *b*, mucosal flap turned down *c*, sectional view, showing outline of flap *d*, lip fixed to bone with Veau twin-needle, one point above and other below mucocutaneous junction (Kirschner)

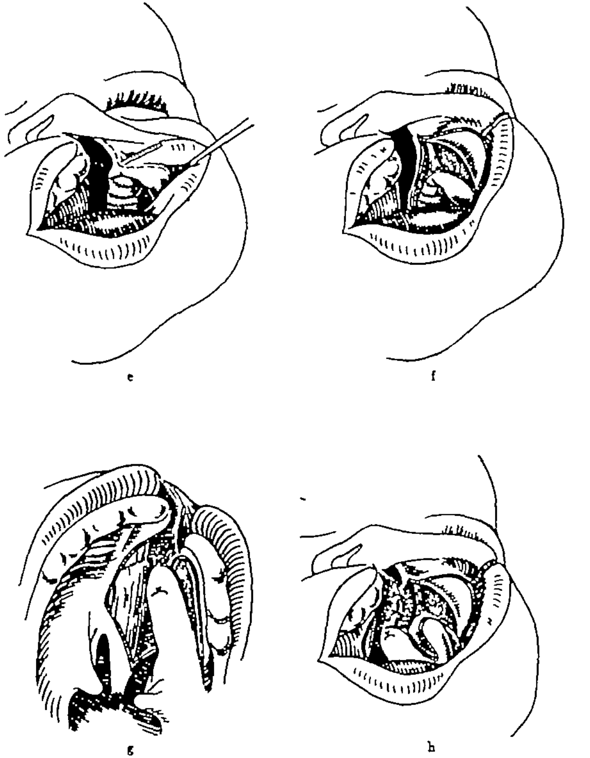
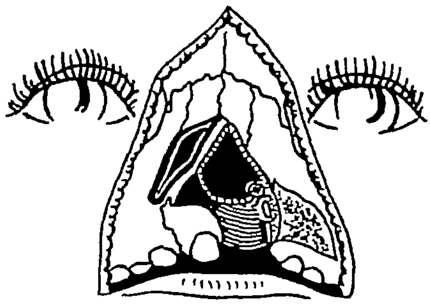


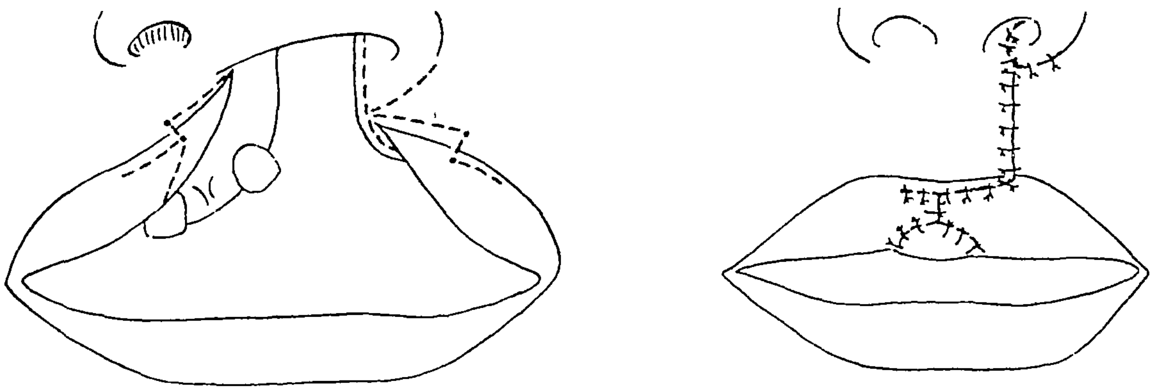
FIG. 781 Veau operation for unilateral alveolar cleft (cont.) *e* area outlined by solid line indicates wedge of tissue at mucocutaneous junction dotted line, incision in vestibule along gingivolabial sulcus. *f* soft parts separated from maxilla up to pyriform process. Nasal mucosa separated from palatal cleft. *g* mucoperiosteal flap sutured to vomerine flap *h*, vomerine flap united to nasal mucosa to reconstruct nasal floor (Kirschner)

to fix the base of the nose in its normal position Finally, the ends of the wire suture are twisted and tightened, to draw the ends of the orbicularis muscle together (fig 779-(48)) The ends are cut off short and turned out

Skin sutures are removed on the fifth or sixth day, and the wire suture and those in the mucous membrane on the tenth day



i



j k

FIG 782 Veau operation for unilateral alveolar cleft (concl) *i*, diagram, showing reconstruction of nasal floor *j*, incisions outlined on lip *k*, wound margins approximated (Kirschner)

Davis' Operation

Davis' operation for the repair of bilateral alveolar clefts is essentially as follows Through an incision along the lower margin of the septum a triangular segment of such size as to permit of posterior rotation of the premaxilla into a normal position is removed from the bone and cartilage The apposing margins of the premaxilla and alveolus are denuded, and the premaxilla is replaced and fixed in position with a wire suture Following this procedure, the margins of the lip defect are denuded and approximated The operation is completed by mobilizing palatal flaps through lateral incisions and shifting them to the midline, the flaps being held in place by tapes passed beneath them The relaxation incisions are packed with iodoform gauze which is removed in 24 hours On the sixth day the tapes are untied and the flaps permanently approximated by sutures of silver wire passed through the anterior portion and of silk in the posterior portion The tapes are then retied to avoid tension on the new suture line One tape is removed on the second or third day and the other on the fifth or sixth Removal of the sutures is begun on the ninth day (fig 783)

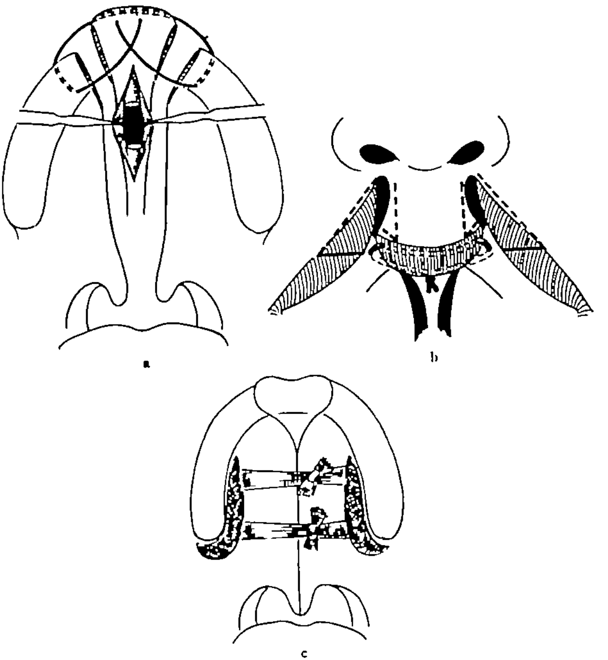


FIG. 783 Davis operation for bilateral alveolar cleft. *a* triangular section removed from septum to permit repositioning of premaxilla. Wire sutures passed, to immobilize bone. *b* frontal view showing position of wire suture and lines of incision on lip *c* palatal flaps shifted inward and immobilized with tape. Relaxation incisions packed with gauze For details, see text. (Bickham)

REPAIR OF SECONDARY DEFECTS FOLLOWING CLEFT LIP AND CLEFT PALATE OPERATIONS

Following cleft lip and cleft palate operations, residual deformities frequently remain requiring surgical or prosthetic correction

Lip Defects

There may be an abnormal *elevation at the suture line* due either to a faulty reconstruction or to a giving way of the sutures or the vertical length of the two sides of the lip from the base of the nose to the free margin may be unequal These defects

are repaired by first excising the scar of the original operation and then readjusting the parts by one of the procedures described for the correction of prealveolar clefts If the vermilion border is irregular, too straight from angle to angle, or unduly narrow, correction is best accomplished by the "Cupid's bow" operation detailed in the chapter dealing with lip deformities (p 1095)

The reconstruction of a lip following a faulty cleft repair is shown in Figure 784

An *abnormal flatness of the lip* following operation may result from a deficiency of

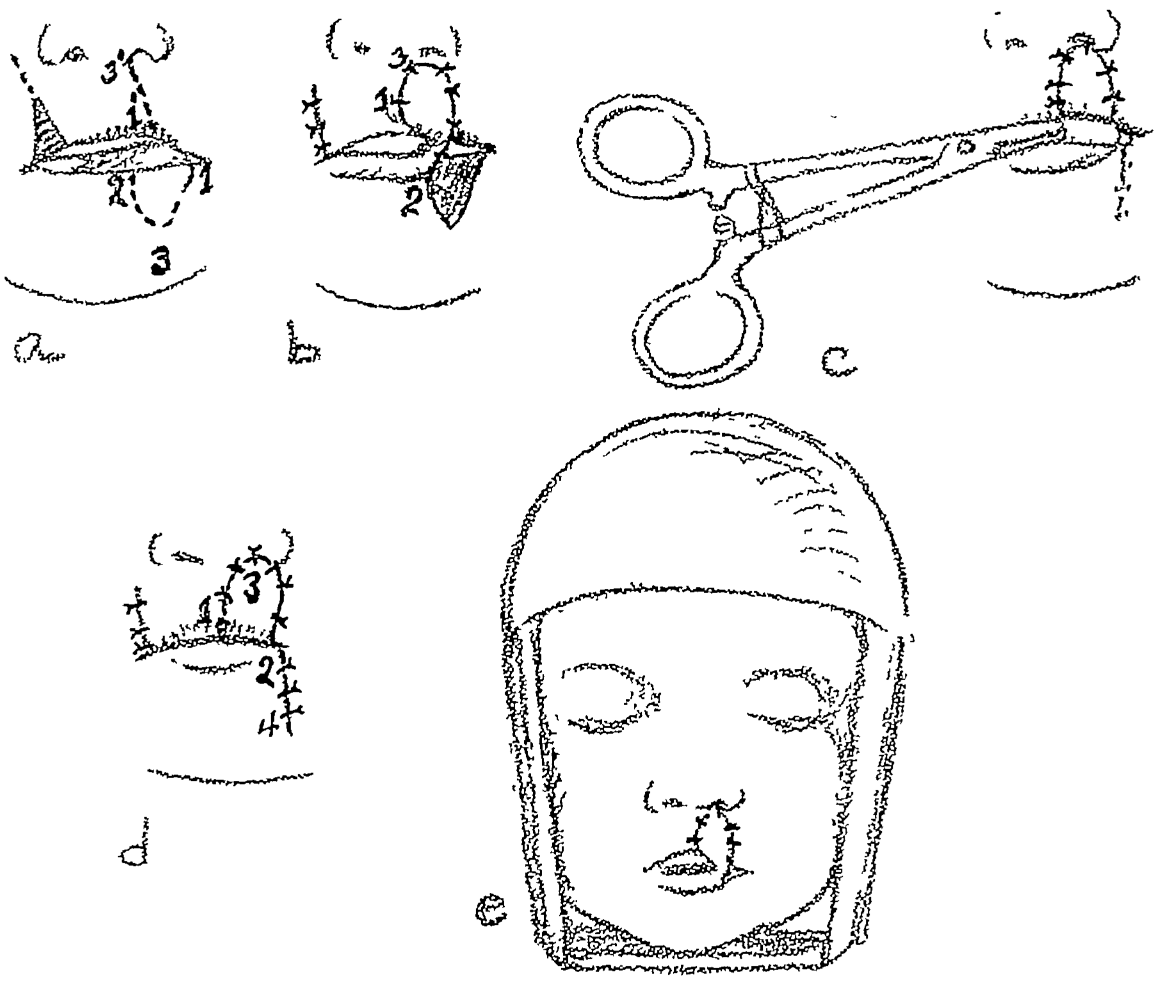


FIG 784 Secondary repair of cleft lip associated with loss of tissue *a*, line *3'–1'*, incision for reception of flap *1–2–3* from lower lip Shaded area represents scar, which is removed and wound margins approximated *b*, flap *1–2–3* rotated into defect and fixed in place *c*, after 2 or 3 weeks, vascularization of flap tested by clamping pedicle *d*, pedicle cut and adjusted *e*, lips immobilized by underchin board held in place by plaster head-cap (Browne)

labial tissue or from the removal or forcible repositioning of the premaxilla If due to a lack of soft tissue, it is corrected by one of the procedures described in the section on lip reconstruction (p 1086) If the foundation is at fault, repair is effected by means of a buccal inlay (40) The technic, which is detailed on page 1187, consists essentially in freeing the nose and lip from the underlying retroposed maxilla and lining the cavity with a razor graft on a stent mold Into the epithelized pocket thus created a denture sufficiently prominent to reproduce the normal contour, conceal the malposed teeth, and equipped with artificial teeth which will articulate normally with those of the lower jaw is introduced

Nose Defects

As a rule, following cleft lip operations there remain certain typical deformities about the nose which require correction After the repair of a unilateral cleft the nostril on the affected side frequently remains flattened due either to a deficient forward projection of the maxilla or to cicatricial contraction of the raw surface consequent upon the undermining resorted to in the cleft lip operation. The septum is not infrequently deviated and lacks forward projection causing the columella to become oblique or retracted and the nasal tip on the affected side to droop In the case of bilateral clefts the columella is often too short and the nasal tip consequently depressed because of undue downward displacement of the columellar skin in the process of reconstruction

The first step in the correction of these defects consists in freeing the nose and lip from their faulty attachments to the subjacent underdeveloped maxilla. The remaining raw surface must be epithelized otherwise irrespective of the amount of undercutting the correction will be only temporary since the subsequent contraction during the process of healing will invariably cause some recurrence of the distortion Prior

Fig. 785 Kilner splint for holding graft-covered mold in place. For details, see Figure 456

to operation a splint carrying a tray with an adjustable upright to be attached to cap-splints around the teeth must be constructed for the purpose of holding the transplant in place (fig 785) There are many types of splints and their construction may be left to the ingenuity of the prosthetist.

The mouth is prepared for operation in the usual manner (p 1067) While an assistant cuts a thin razor graft from the inner side of the arm, the surgeon prepares the bed for its reception The lip is retracted and an incision 5 to 6 cm. long is made along the gingivolabial sulcus on the affected side Through this incision the soft tissues are separated from the superior maxilla as far as the pyriform opening The dissection is continued until the parts can be brought into their normal relationships. Hemorrhage is controlled by pressure with hot gauze packs. An impression of the cavity is then made as follows A piece of modeling compound softened in hot water is placed in the tray on the splint previously constructed, introduced into the pocket, and allowed to harden It is then removed, and a razor graft is wrapped around it, raw surface out. The graft-covered mold is reinserted into the pocket and immobilized by fixing the upright on the tray to the metal bands previously attached to the teeth. At the end of 10 days the mold is removed and the pocket will be found epithelized To eliminate the danger of subsequent contraction the mold is replaced with one of gutta-percha or

vulcanite, and this is worn for about 2 months, after which time no further contraction need be anticipated During this period the mold should be removed daily for purposes of cleansing (fig 786)

With these preliminary details attended to, the subsequent steps will be dictated by the conditions found If the septum is deflected, it must be restored to the midline to serve as a buttress before the lobule and the columella can be maintained in their normal positions, and this is accomplished in the manner described on page 710 Briefly, the

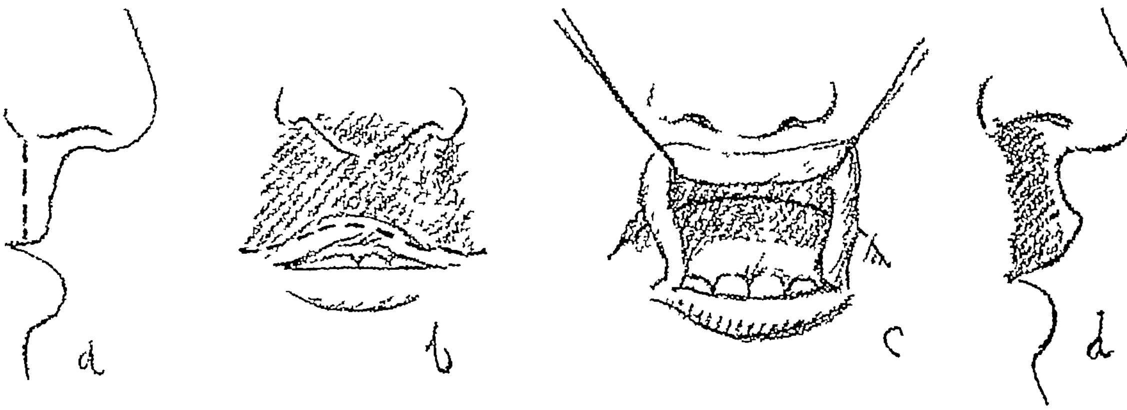


FIG 786 Buccal inlay for correction of retroposed upper lip following faulty cleft lip operation *a–b*, showing extent of mobilization *c*, line of incision for introduction of graft-covered mold *d*, prosthesis in place (McIndoe)

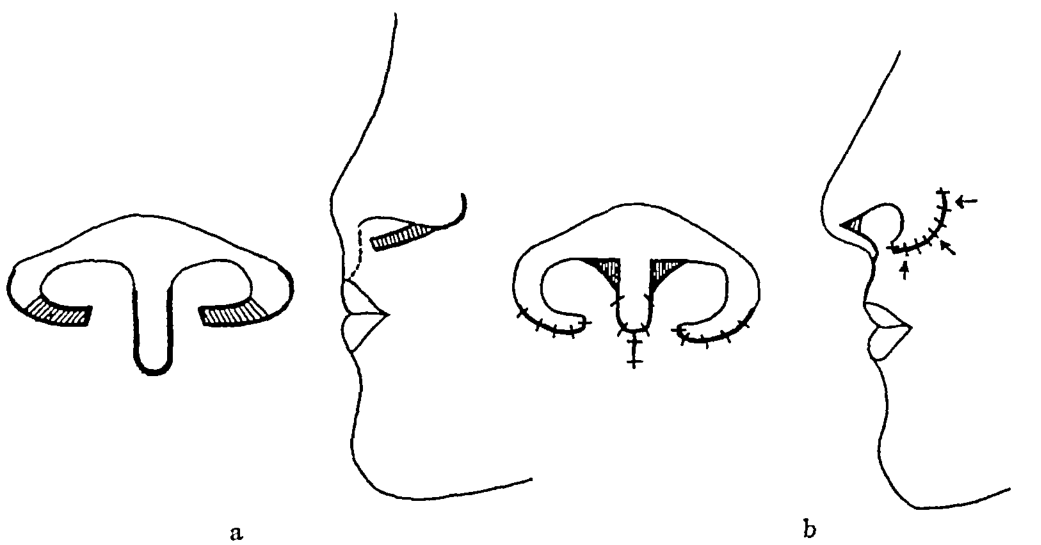


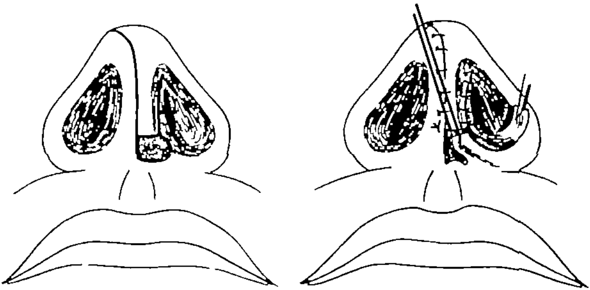
FIG 787 Lexer operation for repair of nasal deformity associated with cleft lip *a*, flap outlined on philtrum, to lengthen columella Shaded areas represent beds prepared for repositioning of ala *b*, philtrum flap raised, shifted to higher level, and attached to septum, thus raising depressed tip Alae rotated inward into prepared beds, thus increasing convexity

perichondrium is freed on the side opposite the deformity, and a ribbon of cartilage is removed at the site of deflection The caudal margin of the septum is then separated from its faulty position on the floor of the nose and is swung into its normal location in the groove of the vomer If the septal projection is deficient, a right-angled cartilage implant may be necessary for the restoration of the profile angle (p 700)

Should the lobule be depressed, owing to the inadvertent incorporation of a portion of the columellar tissue in the labial structures when the cleft lip was repaired, this tissue

must be returned to the columella before the nasal tip can be made to assume its proper projection. This is accomplished by completely detaching the membranous septum from the caudal margin of the septal cartilage and continuing the incision into the lip along both sides of the philtrum for a distance sufficient to insure a normal columellar length (fig 787) The lengthened columella thus outlined is entirely freed from its underlying attachments and shifted forward to a higher level. The V-shaped space left in the lip is undermined far enough to permit of liberation of the alar base One or 2 buried catgut sutures are then introduced, to bring the alar bases together Finally, the elongated columnella is attached to the caudal margin of the septum, and the margins of the wound in the lip are approximated.

If the lower lateral cartilage on the affected side is flattened and separated from its fellow, it is mobilized (p 680), the connective tissue between the angles is removed subcutaneously, and the cartilages are brought into proper alinement and fixed by means of 1 or 2 mattress-sutures of fine catgut. If the cartilage is also depressed, it is



a b

FIG 788 Gillies operation for repair of flattened ala. For details, see text.

elevated and attached with 2 or 3 mattress-sutures to the adjacent upper lateral cartilage.

In severe cases of flattened ala Gillies (40) operates as follows (fig 788) "An incision must be made in the midline of the columella, separating one mesial crus from the other, and carried forward into the tip of the nose curving towards the normal side. It is sometimes necessary to prolong the incision backwards, carrying it around the outturned extremity of the mesial crus and coming out into the vestibule. The mesial crus, having been thus freed is slid forward into correct position and held there by skin sutures It is to be noted that the sliding forward of the half columella in this manner in unilateral cases is comparable to the sliding forward of the whole columella in bilateral cases. To correct the position of the alar base a free incision is required in its lining, through which adequate undermining between it and the maxilla may be carried out In order to free the alar base still further it may be necessary to carry this incision into the alar groove. A deep catgut suture now approximates the

deep tissues of the alar base to the tissue covering the septum and nasal spine Sufficient deep tissue is drawn inwards by this manoeuvre to build up any defect in the vestibular floor, but a raw surface is usually left on the outer wall and this must be covered by either a Thiersch graft or a small transposed flap usually found to be available in the floor of the nose When the half columella has not been advanced, an implacement must be found for the alar base by reflection of a triangular flap from the inner part of the floor of the vestibule It is this triangular flap which is used to cover over the raw surface on the outer wall above the advanced alar base flap There often remains an excess of nostril margin and lining which renders the result still imperfect This can be corrected by excision of an ellipse of the free margin of the cartilage together with its vestibular lining "

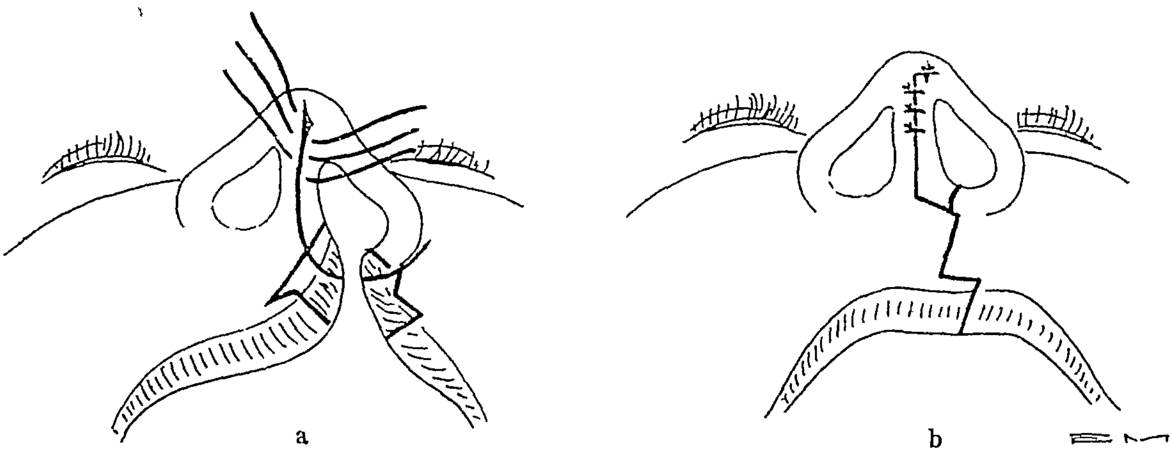


FIG 789 Blair operation for flattened ala *a*, outline of incisions *b*, nostril on flattened side rotated inward Margins approximated

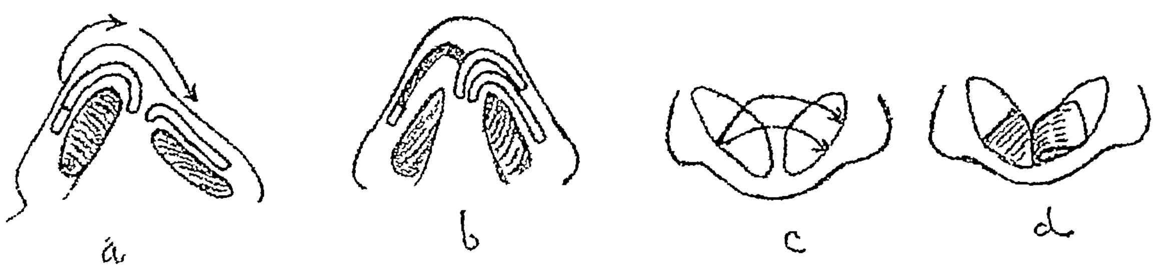


FIG 790 Correction of flattened ala with flap taken from opposite lower lateral cartilage *a*, skin over lower lateral cartilages freed through intranasal incision *b*, lateral crus of cartilage on unaffected side cut and folded over, to build out flattened side *c–d*, frontal view (Humby)

Blair (7) cites a case in which he corrected a flattened ala in a 17-year-old patient by "splitting the columella between the cartilages, rotating the right nostril into proper position, and opening and resuturing the lip At a second operation the lips and cheeks were freed from the septum and the maxillae, and this mass of soft tissues were advanced on the underlying bony and cartilaginous framework and sutured in this new position After healing, a prosthesis that carries cuspid and incisor teeth and which holds forward the upper lip was made by her dentist" (fig 789)

Humby (45) suggests folding a portion of the alar cartilage from the normal side over the flattened side to serve as support for the depressed lobule The skin above the lower lateral cartilages is freed through intranasal incisions made below their lower

margins, and the cartilage on the normal side is cut and folded over into the space created on the flattened side between the cartilage and skin (fig 790) The steps of Kazanjian s operation are shown in Figure 791

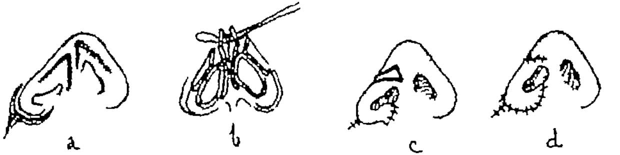


FIG. 791 Kazanjian operation for correction of flattened ala. *a* ala freed from cheek. *b* lateral crura cut and sutured together at higher level. *c*, triangular section removed from ala, to improve contour *d* ala rotated and sutured to inner side of septum Wound margins approximated.

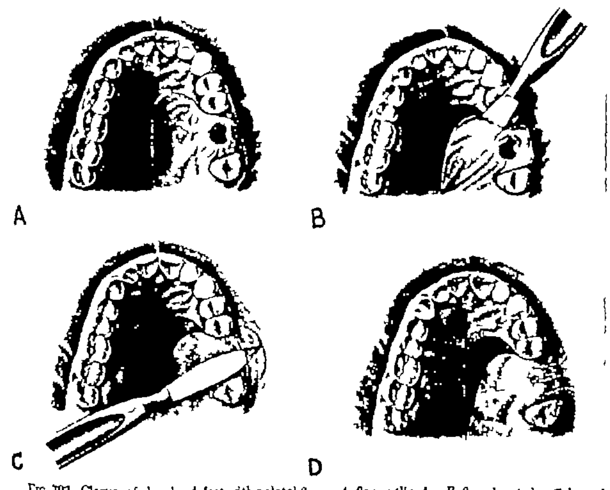


FIG. 792 Closure of alveolar defect with palatal flap *A* flap outlined. *B* flap elevated. *C* buccal flap raised. Lateral edge of palatal flap denuded and tucked beneath it *D* flaps sutured together (Dunning, Medical Dept U S Army Vol. XI)

After the correction of the lower cartilaginous vault the osseous and upper cartilaginous pyramid will usually be found to be out of alinement. The method employed in bringing these structures to the median line is described on page 691

Palate Defects

If the primary operation on the palate proves unsuccessful, either as a result of non-union or sloughing of the flaps, secondary repair should not be undertaken until 3 or 4 weeks have elapsed The method to be adopted will depend upon the amount of available soft tissue remaining on the palate In the event of complete failure, con-

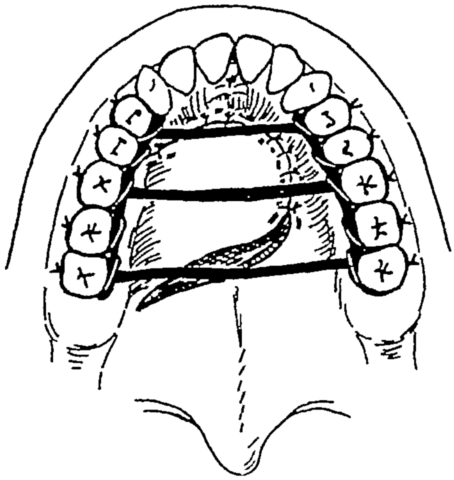


Fig 793 Closure of anterior palatal defect with palatal flap Contiguous palatal flap shifted ove defect and sutured in place Protection afforded by wire frame anchored to teeth (Ganzer)

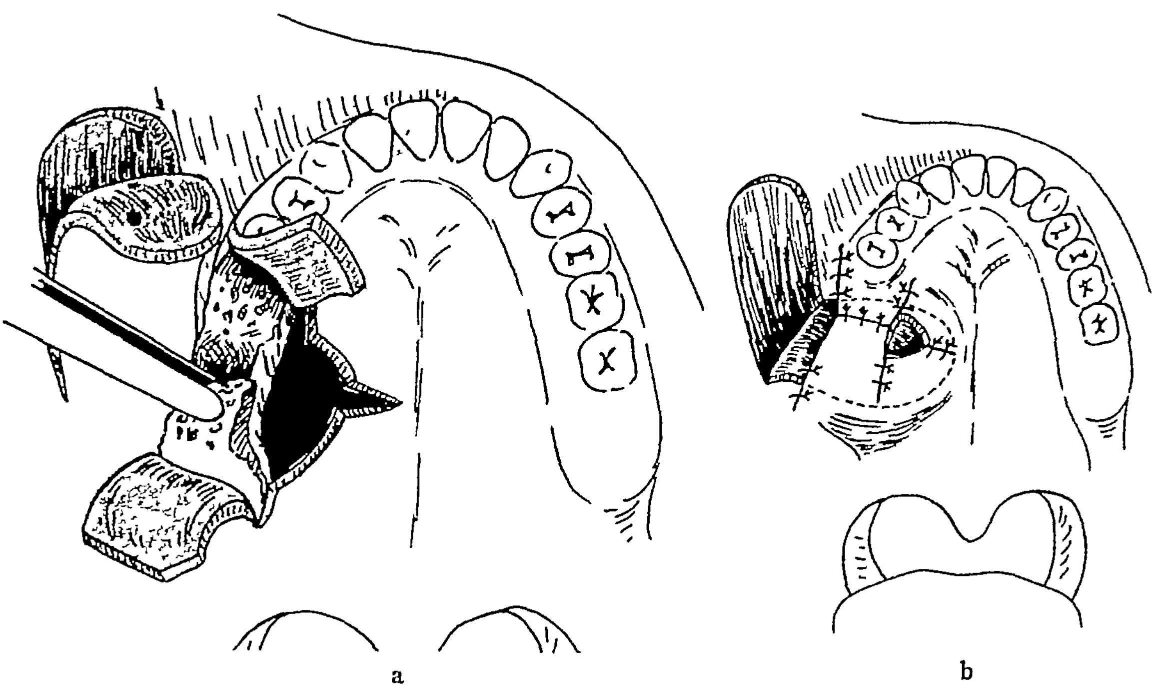


Fig 794 Closure of alveolar defect in posterior quadrant *a*, mucoperiosteal flaps raised Alveolar ridge trimmed Borders of defect freshened Cheek flap raised *b*, cheek flap turned in for lining *Raw surface covered by approximation of mucoperiosteal flaps over it* (Rosenthal)

ditions permitting, the original procedure is repeated, but the reconstruction will be found much more difficult, owing to the rigidity and fibrosis of the tissues resulting from the previous operative trauma The elimination of small midline defects, which are usually found at the junction of the hard and soft palates, is simple In many instances closure may be accomplished by touching the margins of the defect with silver nitrate

Where sufficient tissue is available, a small flap pedicled on the margin of the defect may be raised from the palate, turned over, raw side out, and placed in a pocket beneath the mucous membrane on the opposite side, the remaining raw surface being covered with a contiguous palatine flap. The principle of Dunning's procedure designed for closure of an alveolar opening communicating with the maxillary sinus can frequently be used to advantage in the closure of small palatal defects (figs. 792–793)

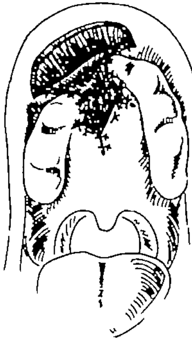


FIG. 795 Closure of anterior palatal defect. Flap from lip pedicled on fornix, turned over defect, tucked beneath palatal mucosa, and sutured in place. (Rosenthal)

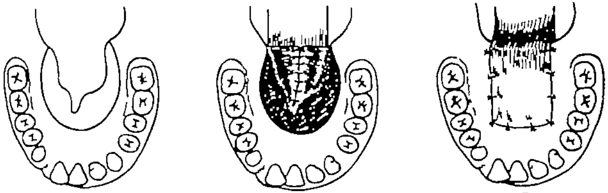


FIG 796 Closure of posterior palatal defect. *1* mucosal flap outlined around defect. *2*, flap turned in and sutured in midline, to form lining *3* pharyngeal flap employed for cover (Padgett)

If palatal tissue cannot be spared, small flaps of mucosa from the mouth, vomer, lips, or cheeks may be employed (figs. 794–795) Rosenthal (75), to close a large defect in the soft palate, raised a flap 1 to 2 cm wide from the posterior wall of the pharynx, and after denuding the margins of the defect in an oblique manner to furnish a broad raw surface for approximation sutured the flap in place and protected it with a wire frame anchored to the teeth. The margins of the secondary defect were approxi

mated directly Procedures used by Padgett for the closure of such defects are shown in Figures 796–798

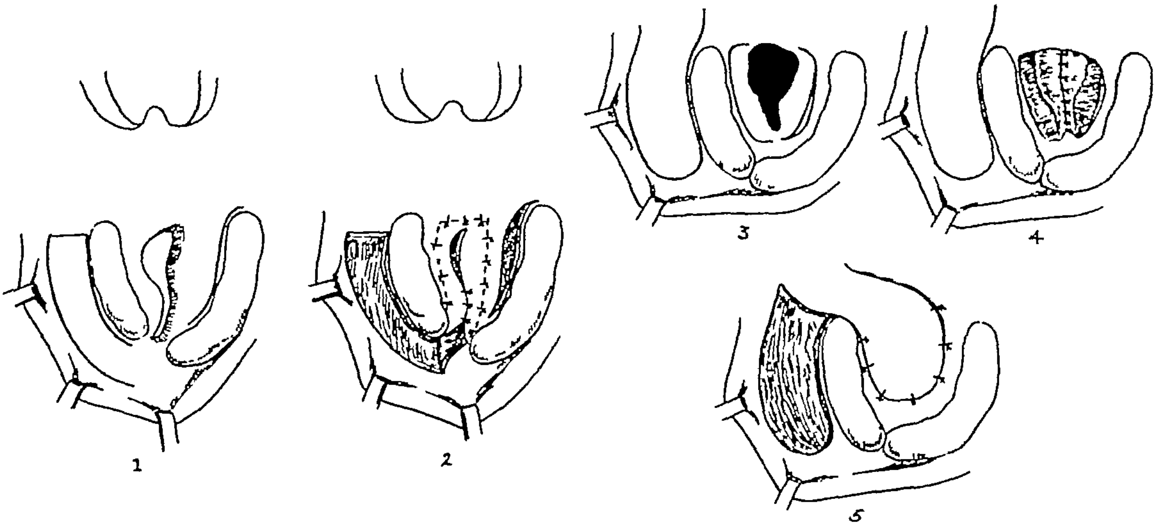


FIG 797 Closure of palatal defect with cheek flaps *1*, cheek flap outlined Incision made along alveolus on opposite side, to permit shifting of mucoperiosteal flap to midline *2*, cheek flap turned, mucosal side in, to form lining Cover supplied by mucoperiosteal flap shifted inward *3*, mucoperiosteal flaps outlined for lining, and cheek flap for cover *4*, mucoperiosteal flaps turned in and sutured to each other *5*, raw surface covered with cheek flap (Padgett)

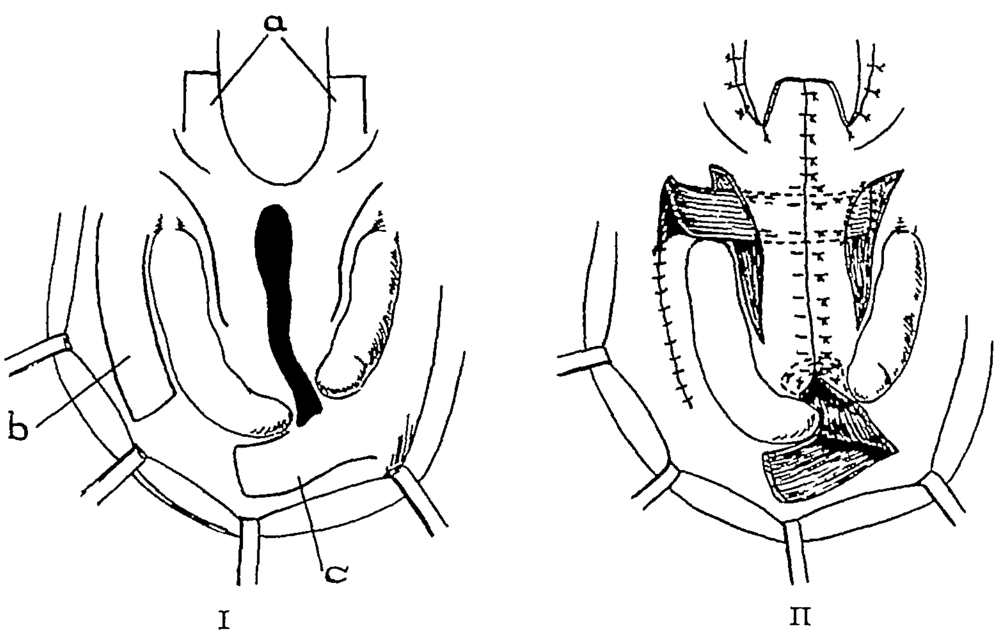


FIG 798 Closure of long narrow palatal defect with simultaneous elongation of palate *Ia*, relaxation incisions made in posterior pillars *b*, cheek flap outlined *c*, lip flap outlined Relaxation incisions made on either side of cleft *II*, cheek flap raised and rotated over posterior part of cleft Lip flap turned over anterior part Raw surface covered by approximation of mobilized mucoperiosteal flaps Posterior pillars approximated, to elongate palate (Padgett)

For the repair of complete losses of the hard and soft palates extra-oral tissue in the form of lined forehead flaps (76), arm flaps (75), neck flaps, and cheek flaps have been used (figs 799–801) These flaps are introduced either by way of the mouth (8, 65, 76, 83), or through an opening beneath the mandible (47) While palatal repair by these

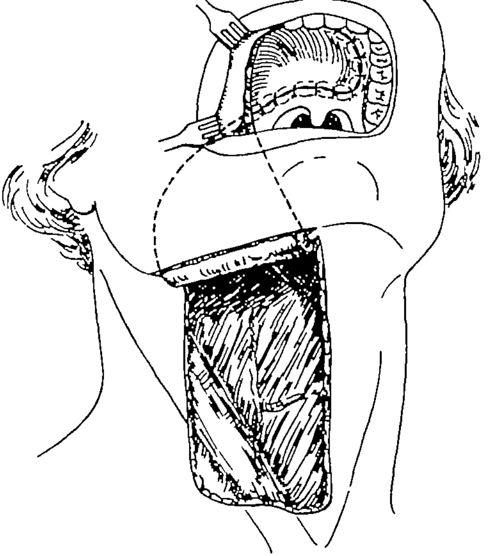
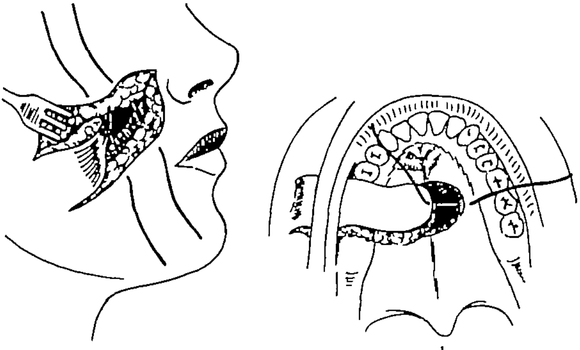


FIG. 799 Repair of palatal defect by previously skin-lined neck flap introduced through incision beneath mandible. (Kappis)



a b

FIG. 800 Repair of palatal defect by cheek flap. *a*, full thickness cheek flap turned into mouth. Sutures passed for approximation of secondary wound. *b* flap sutured into pared margins of defect. (Rosenthal)

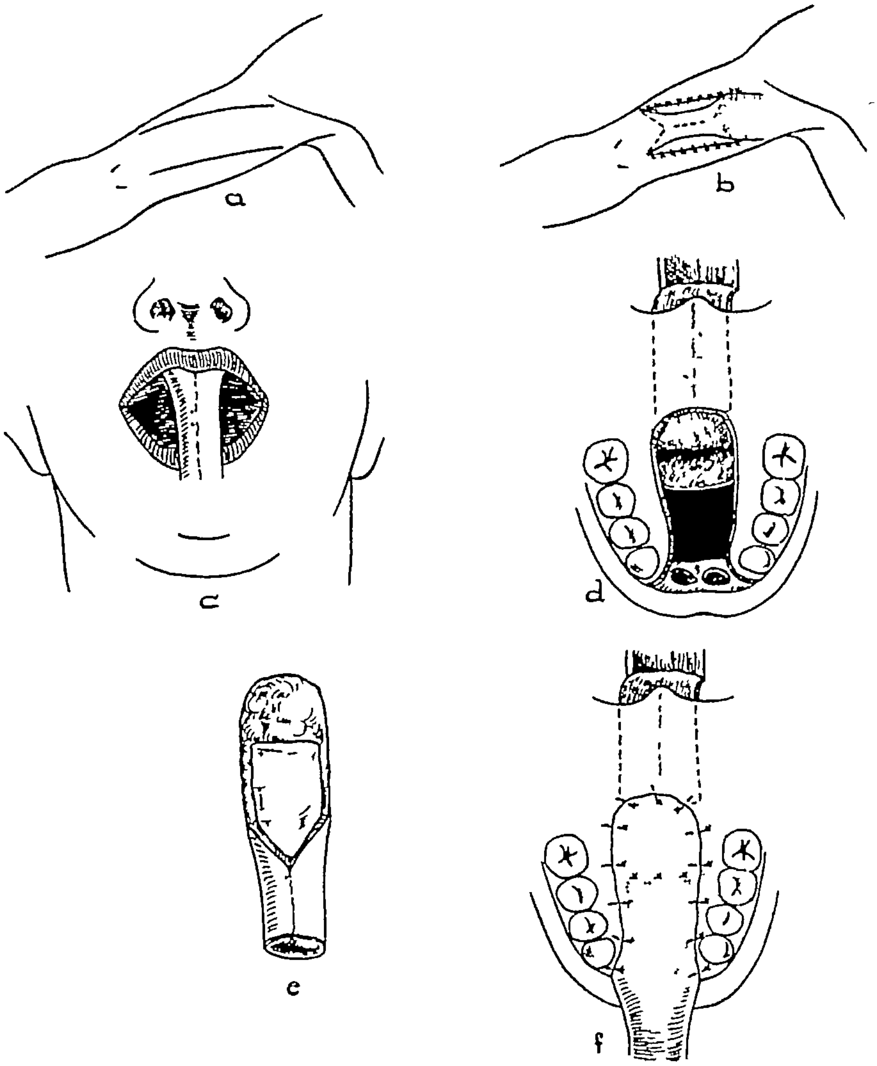


FIG 801

FIG 802

methods offers no technical difficulty, probably an obturator would serve the purpose just as well (fig 802)

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Fig 801 Repair of palatal defect by arm flap *a* flap outlined. *b* upper end of flap skin-grafted on stent mold. Remainder of flap tubed. *c* method of introducing flap *e*, appearance of flap before it is sutured into defect. *d* flap turned down from soft palate, to provide wide raw area for attachment of extra-oral flap. *f*, pharyngeal and extra-oral flap sutured in place. (*Padgett*)

Fig 802. Closure of large palatal defect by vulcanite prosthesis. *A* frontal view showing complete loss of premaxilla and upper teeth. *B* profile view showing resultant recession of upper lip. *C* cast of defect, showing communication between oral and nasal cavity *D* obturator to cover defect and supply lost teeth. *E*, prosthesis in place. *F* profile view showing restoration of contour (Medical Dept., U S. Army Vol. XI.)

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CHAPTER XVII
THE MANDIBLE

ANATOMIC CONSIDERATIONS

The mandible, the only movable bone of the skull, forms the lower third of the facial skeleton articulating above through a pair of condyles with the glenoid fossae of the temporal bones, and below with the maxilla by means of the teeth It gives attachment to the muscles of expression articulation and mastication While its exposed position and powerful muscular attachments predispose it to fracture this tendency is counteracted by its horseshoe shape which endows it with the properties of a spring, and by its bufferlike articular cartilages, compact structure and free mobility

The mandible consists of a curved and nearly horizontal body anteriorly, and two vertical portions or rami posteriorly The *body*, convex in front and concave behind, is composed of two symmetrical lateral halves, whose symphysis or union in the mid line is marked on the external surface by a faint vertical ridge which expands below into the triangular mental protuberance or chin This part of the bone is thick and is rarely broken. Midway between the upper and lower borders and in line with the second bicuspids, is the mental foramen, transmitting the mental nerve and vessels from the dental canal Because of the weakness of the bone at this opening it is a common site of fracture. The internal surface gives origin to the geniohyoglossal muscles, the geniohyoid muscles and the anterior belly of the digastric. It shows the internal oblique line or mylohyoid ridge, passing backward and upward to the ramus. This gives origin to the mylohyoid muscle which forms the main support for the floor of the mouth and to the superior constrictor muscle and the pterygomaxillary ligament. The superior or alveolar border on either side of the symphysis contains the sockets for the roots of eight teeth and externally gives origin to the buccinator as far forward as the first molar The inferior border thick smooth, and rounded, projects beyond the upper and is grooved for the facial artery near its junction with the ramus.

The *ramus* is quadrilateral and thinner than the body The masseter muscle is inserted on its outer surface. On its inner surface, about midway is the inferior dental foramen leading to the inferior dental canal which contains the inferior dental vessels and nerves. These vessels and nerves communicate by a series of fine channels with the apex of each tooth socket. The inner edge of the foramen is sharp and prominent, forming the lingula which gives attachment to the sphenomandibular or long internal lateral ligament of the jaw Between the mylohyoid groove and the angle the internal pterygoid muscle is inserted on a rough triangular space

The junction between the ramus and the body forms the *angle of the jaw* (which is usually slightly everted) and gives attachment posteriorly to the stylomandibular fold of fascia. It is well protected by muscles The degree of the angle varies at different ages. Thus at birth it is approximately 175 degrees, at the age of about four years it is reduced to 140 degrees in adults it is reduced to 120 to 110 degrees or even less.

In old age the alveoli undergo absorption, and the angle is increased to 140 degrees or so, thus allowing the gums to meet

The sharp, concave upper border of the ramus is known as the incisura mandibularis (sigmoid notch) This separates two processes and is crossed by the masseteric nerve and artery. The posterior process, or *condyle*, surmounts the posterior border on a constricted portion, or neck, and gives attachment to the external pterygoid muscle The condyle is convex and transversely elongated on an axis which, if prolonged, would meet that of its fellow near the front of the foramen magnum Its prominent outer end, beyond the articular surface, forms a tubercle to which the external lateral ligament is attached The anterior or *coronoid process* tapers upward and outward in front of the sigmoid notch and gives attachment to the temporal muscle This process is well guarded against injury, owing to the depth at which it lies and the protection afforded by the zygoma

The *muscles* which elevate the mandible are the masseter, temporal, and internal pterygoid, those which depress it are the digastric, mylohyoid, geniohyoglossus, platysma, and external pterygoid, those which cause it to protrude are the external pterygoid, anterior fibers of the temporal, and superficial fibers of the masseter, those which effect its retraction are the posterior fibers of the temporal muscles, the deep layer of the masseter, and the internal pterygoid, and those which produce its grinding motion are the pterygoid muscles acting alternately. The muscles largely responsible for displacement of the fragments following fractures of the mandible are the following (1) The temporal muscle, originating in the temporal fossa and fascia as a thin fan-shaped structure, its fibers converging into a tendinous band to be inserted into the coronoid process (2) The masseter, arising from the lower anterior two-thirds of the zygoma and inserted into the lower half of the external surface of the ramus as far as the angle (3) The internal pterygoid arising from the pterygoid fossa and tuberosity of the maxilla and inserted into the lower half of the inner surface of the ramus, extending to the angle and the mylohyoid ridge (4) The external pterygoid, springing from the under surface of the great wing of the sphenoid, pterygoid plate, and tuberosity of the maxilla and inserted into the condyle and meniscus All of these muscles are innervated by the third division of the trifacial nerve, and their blood supply is derived from branches of the internal maxillary artery (42)

FRACTURES

It has been estimated that fractures of the mandible rank tenth in frequency as compared with fractures of other bones of the skeleton, and third in frequency as compared with the bones of the face That the care of mandibular fractures was well understood in antiquity is evidenced by their mention in the Smith Papyrus, dating from 1500 B C Hippocrates, born 460 B C, stressed the importance of early reduction and immobilization by the use of silk, linen, and gold wire ligatures, indeed, this treatment varies but little from that employed today Celsus, in the early part of the first century, advocated the use of a chin-sling to secure the necessary fixation In 1180 Ruggiero wrote "In fracture of the mandible the lower teeth are not in contact with the upper ones and the patient cannot masticate Then the patient must be taken by the lower jaw and this must be moved here and there until the lower teeth will touch the upper ones" In 1275 Wilhelm suggested that the teeth on either side

of the fracture be fixed to the corresponding teeth of the maxilla. Chopart and Desault (26) in 1750 were the first to use splints, which were in the form of watch-springs placed on the lingual side of the teeth and held in position by means of ligatures passed around the teeth

Today fractures of the jaw are probably more efficiently treated than ever before, and this may be largely attributed to the closer co-operation between the surgeon and the dentist. The latter's ability to interpret the normal occlusion and devise splints capable of securing effectual immobilization without the need of internal wiring has eliminated much of the suppuration sequestration, and scarring formerly so common.

Etiology

The exposed position of the mandible and its lack of support amply explain the relative frequency of fractures occurring in this bone Mandibular fractures are most frequently sustained between the ages of 30 and 40 In children, because of the cartilaginous nature of the bone and the predominance of organic material which permits of bending, they are less common, despite the greater activity at this period of

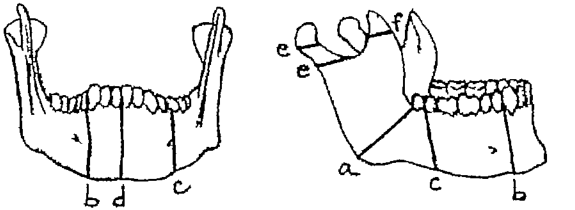


Fig 803 Sites of predilection of mandibular fractures, in order of frequency: *a*, angle *b* mental foramen *c*, molar region *d*, symphysis *e*, condyle *f* coronoid process

life and the physiologic weakening of the mandibular framework by the eruption of the teeth. In the aged, although the bone is brittle and atrophied from loss of teeth the incidence of fractures is low because of sedentary life. Fractures of the lower jaw are said to occur ten times more often in men because of their more strenuous occupations. The determining factor is violence incident to fights, motor accidents, and faulty extraction of teeth. According to statistics furnished by the Cook County Hospital in Chicago, fist fights are responsible for 55 per cent and automobiles for 10 per cent of the cases Occasionally mandibular fractures follow slight traumatisms inflicted on bones already degenerated as a result of infection, osteomyelitis, necrosis, cysts, tumors and general conditions that tend to weaken the structure

The areas of anatomic weakness in the mandible largely determine the location of the fracture The sites of predilection in order of frequency are the angle mental foramen, molar region, symphysis, condyle and coronoid process (fig 803) In children the site most subject to fracture is the canine region, weakened by the unerupted canine tooth Of the bilateral mandibular fractures, according to Donaldson, 77 per cent show a break in the region of the mental foramen on one side and at the angle on the

other. The left side of the jaw is more often injured than the right, due to the fact that blows are usually delivered with the right fist

Mandibular fractures in 98 per cent of cases are compounded into the mouth, owing to the thinness of the mucosa and its close adherence to the bone, and because the root of a tooth commonly lies in the line of fracture In edentulous jaws, while the original fracture is usually simple, the pressure of the splint necessarily employed for immobilization of the fragments often causes necrosis of the overlying soft parts and thus makes the fracture secondarily compound

Diagnosis

Generally speaking, the diagnosis of fracture of the mandible is quite simple A history of trauma, localized pain, swelling, difficulty in opening and closing the mouth, and alteration in the alinement of the teeth present a characteristic picture Areas of localized tenderness referred to a constant point, especially when aggravated by lateral compression of the two sides of the mandible, are particularly significant Crepitus can be elicited if the mandible is grasped on either side of the suspected fracture between the thumb and forefinger of each hand and the fragments gently manipulated, but unless the diagnosis cannot be made without such measures, the test for crepitus had better be omitted, since the necessary movement inflicts additional trauma Anesthesia of the lower lip and gums on the affected side indicates involvement of the inferior dental nerve and serves to corroborate other findings

X-ray examination is of inestimable value in revealing the existence, number, site, and direction of the fracture lines, and in locating foreign bodies, such as loosened, impacted, and infected teeth and spicules of bone in the injured area It is also helpful immediately after reduction to check the approximation of the fragments, and later to give evidence of the presence of infection and sequestra formation It is not a reliable guide, however, in determining the time at which the splint may be safely discarded, inasmuch as it fails to show callus formation until long after union has taken place In order that a good view may be obtained of the mandible from the angle to the neck, a right and left lateral exposure is made with the head in an oblique position, so that the halves of the jaw do not overlap The symphysis is best shown by a dental film held between the teeth, the rays being directed from beneath the jaw, and the neck of the mandible by a postero-anterior exposure

The situation of the fracture line will determine in a large measure the displacement of the fragments (fig 804) The nearer the midline the fracture occurs, the less the displacement, since in this region the muscular action is more equally balanced In fractures lateral to the symphysis the short posterior fragment is drawn upward and inward by the masseter, internal pterygoid, and temporal muscles, and the long anterior fragment is carried downward and backward by the depressor muscles, namely the digastric, mylohyoid, geniohyoid, and genioglossus In fractures of the ramus and condyle there is little displacement, because here the bone is splinted between the strong masseter muscle externally and the internal pterygoid internally, but if there has been comminution of the bone, shortening occurs between the condyle and angle, causing the chin to rotate toward the affected side

Management

The fundamental principles underlying the treatment of mandibular fractures include (1) first aid treatment, (2) care of the soft parts, (3) care of the hard parts, including (a) restoration of the original occlusion, and (b) immobilization of the fragments, and (4) adequate after-care

First Aid Treatment

The first aid treatment of mandibular injuries is the same as that prescribed for injuries elsewhere in the body and is directed toward prevention of shock, control of hemorrhage relief of obstruction to respiration protection against further displacement of the fragments, and prevention of infection. Shock is treated as outlined in Chapter VI Hemorrhage is usually slight and ceases spontaneously after the parts have been put at rest, but if bleeding is persistent, the wound is cleared of all clots, and pressure is applied with a pad of gauze Interference with respiration may be

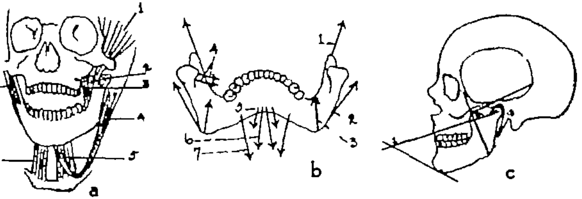


FIG. 804. Muscular force exerted on mandible. *a*, muscular attachments. *1* temporal muscle *2* external pterygoid, *3* internal pterygoid *4* digastric *5* mylohyoid *6* geniohyoid, *7* masseter (Mattl) *b*, showing direction of pull, indicated by arrows. *1* temporal muscle, *2* masseter *3* internal pterygoid *4* external pterygoid *5* digastric *6* geniohyoid, *7*, mylohyoid. *c* diagram, representing lines of force on opening and closing jaw Lines meeting at *1* show pull of external pterygoid and digastric muscles in forced opening Lines meeting at *2* show pull of temporal and masseter muscle in closing mandible. Both lines rotate mandible about midpoint of ramus (Lord)

consequent upon the falling back of the tongue, due to loss of support or to swelling of the tissues on the floor of the mouth and glottis. In the former case breathing will be facilitated if the mandibular fragment is drawn forward and attached temporarily to the upper teeth. In the latter a curved metal airway, inserted into the oropharynx, will relieve the dyspnea.

Should it be necessary to transport the patient before reduction, further displacement of the fragments can be prevented if the teeth are placed in the best possible occlusion, and a temporary bandage applied (fig 805) A strip of dental rubber dam wrapped around the head and mandible serves the purpose well. The four tailed bandage (Barton's bandage) usually employed for this purpose is objectionable, as it not only provides poor immobilization but its diagonal pull tends to increase any displacement already present.

Since practically all mandibular fractures are compounded into the mouth every care should be taken to reduce the chances of infection as soon as the patient's condition warrants the interference The mouth is carefully cleansed with an alkaline

wash Loose, broken, and exposed teeth in the line of fracture are removed, for if allowed to remain they serve as open channels for the spread of infection, delay union, and contaminate adjacent teeth If, however, the tooth is essential as a point of fixation—for instance, in cases where it is the only remaining one in a posterior fragment—it is retained for a week or 10 days until the fragments have attained some stability Under such circumstances, the benefits derived from preserving the tooth outweigh the risk of sepsis Teeth *outside the line of fracture*, if obviously diseased, are extracted, and those still in place are scaled and polished If there is considerable laceration of the soft parts about the line of fracture, dependent drainage is established either through a conveniently situated external wound or through an incision made below the lower border of the mandible Ivy (60) states. "Every fracture that traverses a tooth socket at which there is perceptible motion is compound and should be drained through an external incision made just under the lower border of the jaw This prevents abscesses, delayed union, necrosis or grave sepsis."

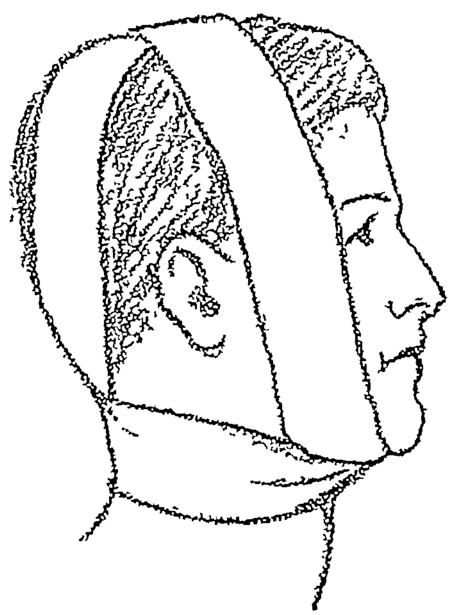


FIG 805 Blair's temporary bandage, designed to hold fractured mandible against upper jaw, without producing backward pressure on fractured body of bone Turns are made as follows Vertex to chin, under chin to occiput, to vertex, to chin, under chin, to occiput, to vertex, etc (Blair and Ivy)

Care of Soft Parts

The care of the soft parts is especially important, owing to their close relation to the oral cavity The details of the procedure are given in Chapter III

Care of Hard Parts

The fundamental principles underlying the management of fractures in general are applicable to mandibular fractures, but in these latter complete reduction is more important, since failure to obtain the most accurate occlusal relationship of the teeth will result in serious interference with function

It is of great importance that mandibular fractures be reduced as soon as the patient has been placed in favorable surroundings and has recovered from shock Early reduction hastens the healing process and lessens the tendency to osteomyelitis

by preventing seepage of saliva into the fracture line Each hour of delay affords an opportunity for swelling and infiltration of the soft tissues, muscular spasms, and the organization of blood-clots between the fragments—all of which have a tendency to fix the bones in vicious positions and increase the mechanical difficulties of reduction. Although a roentgenographic investigation is a valuable aid, nevertheless if the proper facilities for such an examination are not available within a reasonable time after injury, reduction should not be delayed for want of it, since normal occlusion as evidenced by inspection is a satisfactory guide to efficient reduction. As a matter of fact, if the occlusion is correct, the x ray findings may be discounted, even though they reveal the fragments to be in malposition.

Restoration of Original Occlusion. Repositioning of the fragments usually presents no difficulty, the occlusion of the teeth serving as a guide to their proper alinement.

The reduction may be accomplished under general or local anesthesia. If a general anesthetic is to be employed, it is administered intranasally through an endotracheal tube. *A suture is passed through the tongue and maintained in position until the patient has recovered consciousness.* Local anesthesia is obtained by a blocking of the inferior alveolar nerve combined with local infiltration of the part with a 2 per cent solution of procain containing 10 drops of epinephrin to the ounce. The inferior alveolar nerve is blocked by the introduction of a long needle about 1 cm above and 1 cm lateral to the occlusal surface of the last lower molar tooth After the mucous membrane has been pierced, the needle is advanced to the coronoid process, which can easily be felt by a finger placed in the mouth From this point it is directed backward to a depth of 2 or 3 cm., where 6 or 7 cc. of the solution are injected

There is some difference of opinion as to the best position of the jaws during the period of immobilization. In the United States, England, and France the *closed bite* is favored because of the assured normal occlusion, convenience, and ease of fixation This method has certain obvious objections, however notably the inability to masticate, the interference with drainage and oral hygiene and the tendency on the part of the temporomandibular joint to stiffen. The *fixed open bite* (fig 813) permits of more efficient oral hygiene, relaxes the pull of the mandibulohyoid muscles, and prevents ankylosis. But it has the great disadvantage that it leaves an uncertainty as to the occlusion after the removal of the splints, results in some fibrosis and loss of muscle tone, and subjects the patient to considerable discomfort from drooling of saliva and interference with deglutition. Moreover, in fractures posterior to the teeth it does not allow the fragments to lie in their correct relationship during the process of healing, and the V-shaped space existing between them becomes filled with osseous tissue which prevents occlusion when the cast is removed. This form of fixation is beneficial only in bilateral fractures of the body of the mandible, because in the open bite position the pull of the mandibulohyoid muscles is relaxed. In Germany, Austria, and Switzerland the *functional bite* is preferred, inasmuch as it permits of free inspection, and the small amount of irritation incidental to the movement of the jaws is said to promote callus formation But it necessitates the construction of complicated splints, difficult of application.

Methods of Immobilization. Innumerable mechanical appliances have been devised for maintenance of the fragments in their corrected positions. Most of these contrivances act indirectly on the bone fragments, the teeth being used for anchorage. As a general rule, the best results are obtained from that type of device with which the

individual surgeon is most familiar, since the skill with which the apparatus is applied is more important than its ingeniousness of construction. The necessary qualifications of a splint are that it be comfortable, simple and sturdy in structure, easily adjusted, and permit of prompt access to the mouth in the case of emergency, such as hemorrhage or vomiting

The methods whereby immobilization may be secured are (1) intermaxillary wiring, (2) cast splints, (3) circumferential wiring, (4) combined intra- and extra-oral splints, (5) external bandages, and (6) direct wiring of the fragments

(1) *Intermaxillary Wiring* Intermaxillary wiring is the simplest, most practical, and most convenient means of fixation, provided there is a sufficient number of sound upstanding teeth present in the upper and lower jaws to furnish the proper anchorage (58, 90) The method is applicable in 90 per cent of mandibular fractures It does not necessitate an elaborate apparatus, therefore, immobilization need not be delayed, the patient is not subjected to the discomfort incident to the taking of impressions and the fitting of splints, and the services of a dental technician are not required The technic of application of the wires is simple and rapid, and the teeth are in full view throughout the entire period of immobilization, so that the state of occlusion can be constantly observed In case of emergency the wires can be quickly cut and the mouth opened without disturbance to the main fixation As the wires loosen, they can be tightened from time to time, indeed, in the later stages the slight movement due to loosening is beneficial, in that it tends to stimulate bone regeneration The closed bite, however, as has been previously stated, interferes with drainage, mastication, and oral hygiene, the traction of the wires tends to loosen the anchoring teeth, and the presence of a foreign body next to the gums has a tendency to set up a gingivitis

The use of wires for the immobilization of the jaws in proper occlusion, with the existing teeth serving as points of anchorage, was first practiced by Gilmer (44) (1881), whose technic was as follows Strands of #24 gauge brass wire 15 cm long were passed around the necks of two selected adjoining teeth in both upper and lower jaws. The wires were crisscrossed and twisted to each other until the teeth were brought into normal occlusion The great disadvantage of this method was that in order to gain access to the mouth the entire wiring attachment had necessarily to be destroyed This objection has since been overcome by the use of eyelet wires The wires are applied preferably without the use of a general anesthetic, in view of the possibility of postanesthetic vomiting which might prove dangerous with the teeth fixed The seriousness of such an eventuality has probably been overemphasized, however, as there is ample room for the expulsion of the vomitus between the teeth But for the comfort of the patient, if a general anesthetic is to be employed, the eyelet wires are applied during the period of unconsciousness, and the intermaxillary fixation is completed after the danger of vomiting has passed It is advisable to wire the teeth in pairs, since prolonged tension on one tooth may loosen it from its socket The most convenient teeth around which to pass the eyelet wires are the incisors in front and the premolars on either side, three eyelets being thus affixed to each jaw If the premolars and the incisors are not available, other teeth may be used instead In any event, it is best to avoid wiring the teeth adjoining the line of fracture, as they easily become loosened and are incapable of enduring the strain

Technic of Intermaxillary Wiring Immobilization by wiring is accomplished in the following manner (fig 806). A 15 cm length of #24 gauge Angle's brass wire is bent

around a tenaculum, and with a hemostat two twists are made to form an eyelet. The ends of the eyelet wire are inserted from the labial aspect through the space between the first and second maxillary incisor teeth and are advanced until the eyelet alone remains visible, the ends of the wire projecting lingually One end is then passed around the neck of the anterior tooth and the other around the neck of the posterior so that both ends now emerge on the labial surface. To give stability to the attachment, one end is threaded through the eyelet, after which the free ends are grasped with a pair of hemostats, traction is exerted to draw the wires snugly around the necks of the teeth, and the ends are twisted as tightly as possible, the first twist being made by hand The ends of the wire are cut off short and bent in between the teeth to avoid cutting the lip Another loop is passed in like manner between and around the maxillary premolars on both sides. Similar loops are now placed between and around the corresponding mandibular teeth While upward pressure is exerted on the mandible a 12 inch strand of #24 gauge brass tie wire or stainless steel wire is passed through each of these 3 pairs of eyelets and the ends twisted together until the opposing teeth are in firm nor

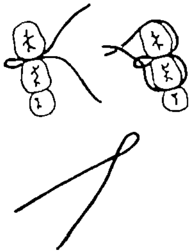


FIG. 806 Introduction of eyelet wires Strand of #24 gauge wire twisted to form eyelet. Ends of wire passed from labial aspect between 2 adjacent teeth. One end passed around neck of anterior tooth other end around posterior tooth and threaded through eyelet. Ends twisted, to draw wires snugly around teeth. (Ivy)

mal occlusion They are then cut off short, and turned in away from the cheeks As a further precaution against irritation from the free ends of the wire, they may be covered with gutta percha or softened stent (58)

In cases where the teeth are insufficient in number or too unstable for the direct application of eyelet wires immobilization may be secured by fixing heavy arched wires around the alveolar arches and fastening them to the existing maxillary and mandibular teeth and to each other with wire ligatures. The use of these arches was introduced independently by Sauer (101) (1889) and Gilmer (45) (1901) The technic of their application is as follows (fig 807) A 12.5 cm. strand of half round German silver wire 2 mm. in width (60) is bent with a pair of hemostatic forceps to conform to the arch of the labial surface of the teeth the ends being turned in to pass around the distal surface of the posterior teeth. The arch bar is then fixed to as many teeth on both sides of the jaw (exclusive of those in the fracture line) as is necessary to insure complete fixation. This is accomplished by encircling the neck of each selected tooth with a 15 cm. length of #24 gauge ligature wire in such a manner that the ends emerge through

the interproximal space on the labial aspect, one end passing above the arch and the other below it The two ends are then tightly twisted together over the arch wire, cut off short, and bent over so as to prevent irritation to the cheek or lips An arch bar is then fitted to the maxillary teeth in a similar manner, and the two bars are connected by means of several strands of #24 gauge brass wire Risdon (97) simplifies the above procedure by fastening a long brass wire firmly around the last molar tooth on each side and then twisting the ends together in front to complete the arch The arch is then secured to the teeth by means of wire ligatures Winter (114) fastens to the teeth a ready-made arch bar equipped on its buccal aspect with lugs for the attachment of wire or elastic bands (fig 808)

Gradual Reduction If the displacement cannot be corrected immediately without undue force, it is better to reduce the fracture gradually than resort to heroic measures. By so doing, a little better alinement is produced each day, less discomfort and pain are occasioned, and the danger of additional trauma to the parts from tearing of the tissues is avoided Gradual reduction may be accomplished in the following manner: The teeth are wired in the usual way, and tie wires are passed obliquely between the upper jaw and the displaced fragments in such a manner that when they are tightened, the movable displaced fragment will be drawn toward the fixed loop on the maxilla

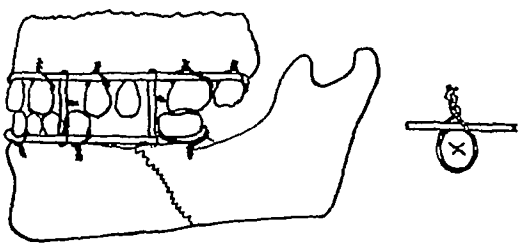


FIG 807 Immobilization of fragments with arch wires fastened to teeth and to each other by tie wires Insert shows method of attaching arch wire to teeth (This method is used when teeth are insufficient or too unstable for direct application of eyelet wires) (Blair and Ivy)

As much traction as possible is exerted on the wires at the time of their application, and at the end of 24 hours, when muscular relaxation will have taken place, this traction is renewed to take up the slack The procedure is repeated daily, until the teeth are brought into proper occlusion

Another method of gradual reduction is by means of elastic traction Rubber bands are passed between the hooked ends of wires and fastened around the necks of selected teeth in the fragments and in the upper jaw in such a manner that tension will be exerted in the proper direction to overcome the displacement After reduction has been accomplished, the rubber bands are discarded and the parts immobilized with a more permanent form of splint Various plans for gradual reduction are shown in Figures 809–811

(2) *Cast Splints* Dental cast splints furnish excellent fixation, even when but few teeth remain in the fragment In many cases these splints provide the necessary immobilization when attached merely to the mandible, thus permitting the patient to open and close the mouth Yet in view of the expense and time necessary for their construction, together with the need of a skilled mechanic, this type of fixation has been largely supplanted by simpler devices It is reserved for those cases in which intermaxillary wiring is impracticable—for example, in children whose teeth are not strong enough to endure the strain of fixation wires, in patients with only a few teeth

in each fragment in some cases of fracture behind the third molar (fig 817), and in comminuted fractures with loss of bone, where fixation has to be maintained over a period of many months. In the latter case separate cap-splints are constructed for each fragment and connected by means of a rigid bar which serves to bridge the gap (fig 820)

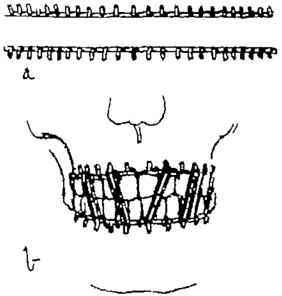
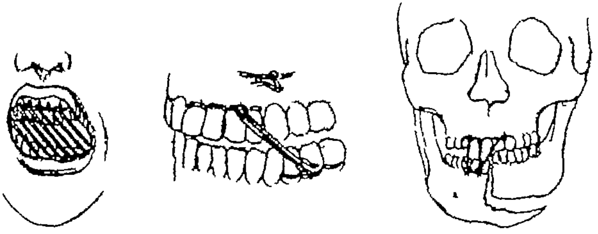


Fig. 808. Immobilization of fragments by wires or elastic bands stretched between lugs on arch bars. a, arch bars for upper and lower jaws b bars attached to teeth and held together with elastic bands stretched between lugs. (Winter)



a b c

Fig. 809 Gradual reduction of mandibular fractures by wire or elastic traction bands stretched obliquely between jaws in such a manner that, when tightened, movable displaced fragment will be drawn toward fixed maxilla. a mandible displaced to left. Rubber bands stretched obliquely between hooks fastened to teeth, to exert traction toward midline (Padgett) b mandible displaced backward Bands passed between hooks on premolars in maxilla and molars in mandible, to carry jaw forward (Ernst) c, mandible displaced downward Rubber bands stretched between incisors of upper and lower jaw Instead of rubber bands, wire ligatures may be applied and gradually tightened to effect reduction. (Ivy and Curtis)

The first step in the construction of a cast splint is the making of negative reproductions of the upper and lower jaws either in plaster of Paris or wax Positive models are then made by pouring plaster into these negative impressions. If the fracture can be reduced, the plaster impression of the teeth and alveolus is taken while the fragments are held in the corrected position. Otherwise, the impression is taken of the

jaw in its existing condition The lower model is cut through at the site of the fracture, set up on an articulator, and arranged in normal occlusion with the teeth of the upper cast, after which the sections are cemented together With this as a model, a splint is constructed in metal or vulcanite and fixed to the teeth as soon as the displaced mandibular fragments have been reduced

Many types of cast splints are available There are those designed (a) for attachment to the lower jaw alone, and equipped with jackscrews and springs to serve the purpose of gradual reduction, and with saddle attachments to take care of an edentulous posterior fragment (15) (fig 820), and (b) those to be attached to both jaws and carrying hooks or lock pins by means of which the teeth may be fixed in normal

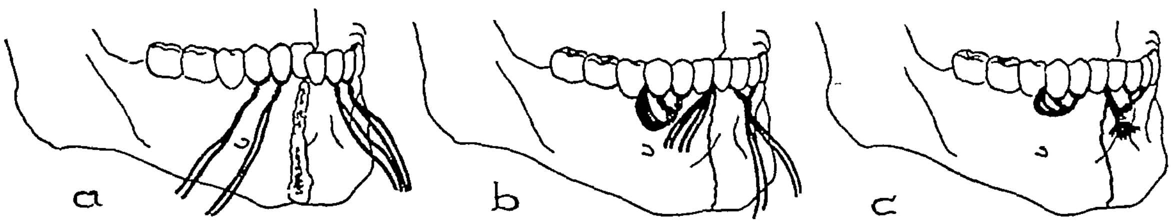


FIG 810 Reduction of overriding mandibular fracture *a*, wire twisted around selected teeth in both fragments *b*, wire in displaced side passed around distal side of bicuspid, made to follow lingual surface of teeth toward median line, and brought out proximally *c*, wires gradually tightened, to correct backward displacement. (Kazanjian)

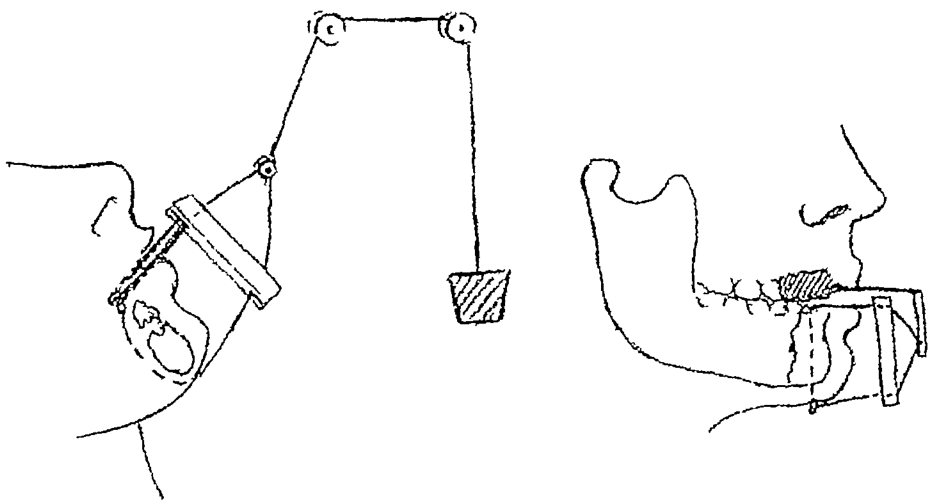


FIG 811 Gradual reduction of mandibular fracture by skeletal traction *a*, circumferential wire passed around bone and attached to counter-weight working pulley fixed to bed or ceiling (Blair) *b*, wire passed around bone and attached to outrigger fixed to upper teeth or head-cap (Barsky)

occlusion (17, 18, 19) This type of splint may also be equipped with a metal flange or a sliding sleeve and post arrangement for the correction of a tendency on the part of the mandible to swing over to one side The former device engages the teeth of the upper jaw and acts as an inclined plane to throw the teeth into proper occlusion when the jaws are closed, the latter is so constructed as to permit movement of the jaw in a vertical direction only

The cast splints most commonly employed are the following: The *Hullihen* (54) *splint*, consisting of a continuous tooth-cap splint of silver, cast to fit accurately over the teeth in each fragment and cemented into place after the fracture has been reduced This type of splint is applicable only when firm teeth are present in each fragment, and when there is little tendency on the part of the fragments to become displaced When

additional fixation is necessary a similar contrivance may be cemented to the maxillary teeth the two splints being united by wires passed between lugs on their anterior surfaces. The *Gunning* (48) *splint*, comprising two gutter-shaped casts of light metal or vulcanite united by means of lateral supports and immobilizing the jaw in an open bite. The upper cast is fitted over the maxillary alveolar arch and the lower to the fractured mandible the whole being supported by means of a circular bandage passing around the head and under the chin. This splint finds its greatest application in fractures of edentulous jaws. It cannot be used in fractures near the angle, since like all open bite splints it does not allow union of the fragments in the correct position, and as ossification takes place the triangular gap between the separated bone fragments becomes filled with new bone and holds the jaws apart. The *Kingsley* (69) *splint*, a modification of the Gunning splint being equipped with lateral wings In the application of this device the chin is used as a point of fixation

(3) *Circumferential Wiring* Circumferential wiring of the fragments contemplates the passing of wires around the body of the bone, and twisting them over a splint fitted to the lower alveolar ridge (10) This method of fixation must be resorted to in cases where the teeth are either entirely absent, too few in number, or too insecure to afford attachment for ligature wires and also in bilateral fractures of the body of the mandible associated with marked displacement. The fracture is reduced and an impression taken. From this a cast is made in vulcanite or metal to fit like a saddle over the alveolar ridge, extending beyond the fracture on either side. If the patient already has an artificial denture, this may serve the purpose of a splint.

Technic of Circumferential Wiring (*fig* 812) A small incision is made just below the lower border of the mandible lateral to the line of fracture. Through this opening an antrum trocar and cannula is inserted and passed close to the inner surface of the bone until the mucous membrane of the floor of the mouth has been pierced. The trocar is then removed, and one end of a # 24 gauge brass wire is introduced from below through the cannula until it appears in the mouth The cannula is withdrawn, leaving one end of the wire projecting into the mouth on the lingual side of the bone and the other protruding from the skin incision The trocar and cannula is then passed from above downward close to the bone on the labial side until it emerges through the original incision. The trocar is removed, and the end of the brass wire issuing from the opening below the mandible is passed through the cannula The wire now loops around the bone, the two ends projecting into the mouth The vulcanite splint or denture is then applied, and the ends of the wire are twisted over it. Another wire is similarly passed around the other fragment and likewise tightened over the splint. When both fragments have been immobilized, the small skin incision is closed. These wires are not removed until union of the fragments has taken place.

(4) *Other Methods of Fixation* *Combined oral and extra-oral splints* consisting of a metal tray fitted over the mandibular teeth and attached by a bar to a cup beneath the chin have fallen into disuse since with this device it is impossible to maintain the fragments in the correct position, there is danger of necrosis of the soft parts from pressure, and in case of infection drainage is impeded

Fixation by means of *external bandages* with or without some form of cup beneath the chin, the vertex serving as a point of fixation, has also been generally discarded, inasmuch as these bandages cannot be applied tightly enough to maintain immobilization

of the fragments, and in addition they tend to dislocate the chin backward They are used only as temporary emergency supports to hold the fractured mandible against the upper jaw and as supplements to other forms of fixation

The mass of surgical opinion cannot too strongly condemn the practice of direct fixation of the fragments by means of *internal wires and plates* In view of the fact that practically all mandibular fractures are compound, a foreign body introduced into the tissues sets up a chronic inflammatory process which leads either to infection or to absorption of lime salts resulting in interference with callus formation In time these bodies are spontaneously expelled or must be extracted Magnuson (83) quotes J B Murphy's reply to a question of how many Lane plates he removed "Eight out of every ten I put in and I don't know who takes out the other two" Occasionally,

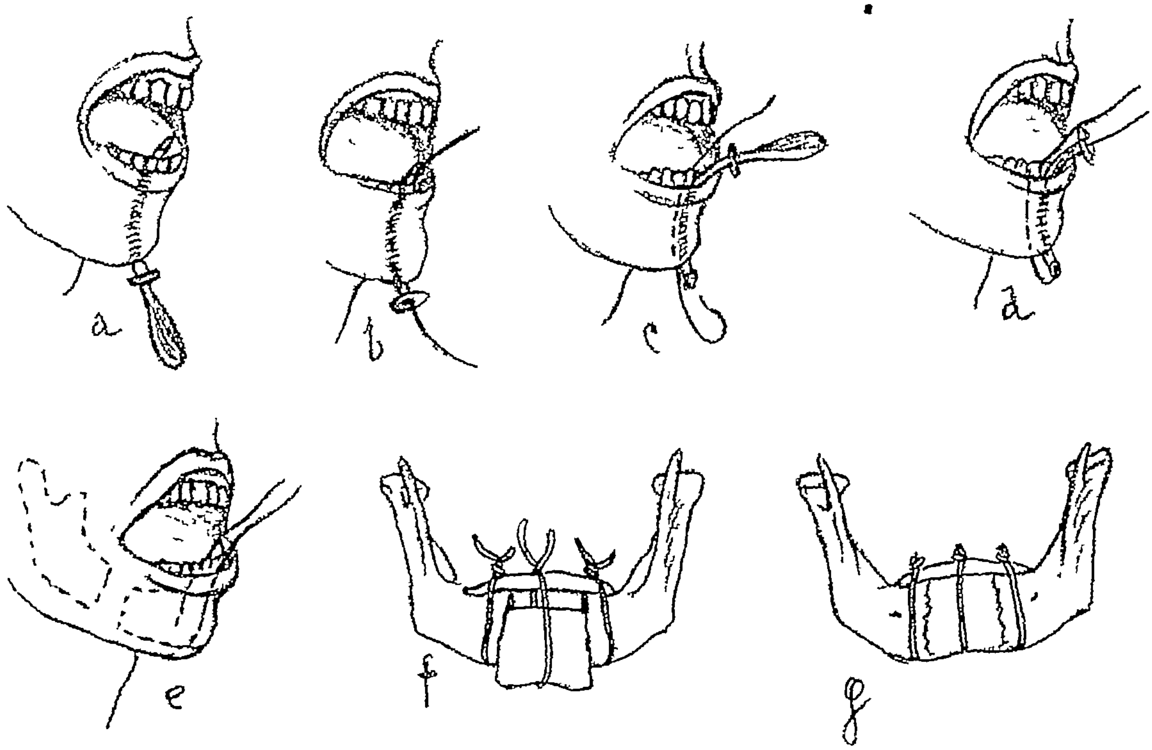


FIG 812 Immobilization of fragments by circumferential wiring—resorted to when teeth are absent or too insecure to afford attachment of ligature wires *a*, antrum trocar and cannula passed from beneath jaw into mouth on lingual side of bone *b*, wire threaded through cannula *c*, trocar and cannula passed on outer aspect of bone *d*, wire passed through cannula *e*, wire in place *f*, double fracture of edentulous mandible immobilized by circumferential wiring over vulcanite denture *g*, effect of tightening wire For details, see text (Ivy and Curtis)

internal fixation is applicable in simple fractures of edentulous jaws, but even here such devices rarely furnish sufficient stability to justify their use

After-Care

As a precaution against infection during the period of fixation, the patient is instructed to keep the oral cavity as clean as possible by frequent antiseptic sprays and to brush the teeth with a mouthwash after each meal Gentle stroking massage is very beneficial and should be instituted as soon as the danger of displacement of the

fragments has passed. It should not be carried to the point of pain, however, since this would entail harmful stretching and tearing of the soft parts.

The *diet* must necessarily be liquid or semisolid and must be of sufficient caloric value to maintain the patient's normal weight and prevent constipation. This necessitates supervision, experimentation and study of each particular case. Adults weighing 70 kilograms require a daily intake of 2500 to 3000 calories which should be administered in such proportion that the chemical balance of the tissues will remain undisturbed. The proper ratio is proteins 100 grams, which will furnish 400 calories, fat 50 grams, representing 450 calories, and carbohydrates 500 grams, amounting to 2000 calories (40). This caloric intake is equivalent to 2 quarts of milk, 6 eggs, and 2 pints of thick soup a day. Additional liquids may be supplied in the form of orange juice and other fruit juices. A variety of food will be required to sustain the patient's appetite. It should be well cooked and should be flavored and seasoned to tempt the palate. Meats may be prepared with a kitchen meat chopper. The most convenient method of introducing food is through a feeding cup equipped with 2 inches of rubber tubing attached to the spout. The tube is passed behind the last molar tooth or through an empty socket. If for some reason food cannot be administered in this manner it may be delivered by way of a soft greased #14 catheter passed into the pharynx through the inferior meatus of the nose and anchored on the face with adhesive tape to prevent its being lost.

The following sample liquid and semisolid diets are suggested by Scogin (107).

Liquid Diet

		Calories
Breakfast.		
Orange juice	1 glass	100
Cream of wheat	¾ cup	100
Cream	40 grams	75
Cocoa	1 cup	300
		575
10:00 A.M.		
Eggnog	1 glass	200
Dinner:		
Cream of celery soup	1 cup	160
Add to soup		
Beef, finely ground	1 tablespoon	130
Purée of sweet potato	1 potato	135
Purée of spinach	¼ cup	25
Milk to thin potatoes and spinach	80 grams	55
Note: Milk is an entirely satisfactory food beverage for these cases.		
Boiled custard	1 cup	300
Tea with 40 grams of cream	1 cup	75
		880

Supper		
Chicken broth	1 cup	100
Add to broth		
Mashed potatoes	½ cup	50
Purée of carrots	2 carrots	45
Milk to thin potatoes and carrots	80 grams	55
Purée of fresh peaches	3 med peaches	100
Cocoa	1 cup	300
		650
8 00 P M		
Grape juice	1 glass	200
	Total	2,505

Soft Diet

		Calories
Breakfast:		
Baked apple	1 apple	200
Wheatena	½ cup	75
Cream	40 grams	75
Eggs	1 poached	85
Coffee, with cream	1 cup	75
		510
10.00 A M		
Malted milk	1 cup	200
Dinner		
Cream of asparagus soup	1 cup	200
Baked potato with butter		250
Purée of beets	2 beets	50
Mashed turnips	½ cup	150
Vanilla ice cream	1 portion	200
Cocoa	1 cup	300
Supper:		
Cream of tomato soup	1 cup	100
Mashed potato	½ cup	50
Ground lamb	80 grams	150
Purée of peas	½ cup	120
Tapioca cream	1 cup	355
Tea, with 40 gm cream	1 cup	75
		750
8 00 P M		
Orange juice	1 glass	100
	Total	2,710

The time at which the immobilizing apparatus may be safely dispensed with is obviously important If it is removed prematurely, refracture may ensue, and if allowed to stay on too long, excessive resorption of bone will take place Unfortunately,

no definite rule can be laid down, since the different degrees of healing power in individual patients and the varying extent and nature of fractures necessitate a careful study of each particular case. Roentgenograms cannot be trusted to show the amount of ossification, since clinical union takes place several weeks before it is evidenced by x-ray Tenderness over the site of fracture is a better indication of the maturity of the callus. Generally speaking, in uncomplicated fractures involving no loss of bone the fixation apparatus may be discarded in 4 to 5 weeks Dean (31), and also Ivy and Curtis (61), advise its removal after 43 days, Rogers (99), after 28 days, and Winter (114), after 36 days. In the case of complicated fractures associated with comminution, infection, or osteomyelitis, a much longer time is required, even up to 100 days or more If during the period of immobilization there is a question as to the dental occlusion the splint may be removed temporarily at the end of 2 weeks and the patient instructed to chew soft foods cautiously In the event of malocclusion the callus will still be soft enough to permit of minor adjustments by manipulation.

After the splint has been discarded, there is usually some limitation of motion, due to fibrosis and atrophy of the muscles from the prolonged period of fixation While this stiffness usually disappears spontaneously with the normal movements of mastica-

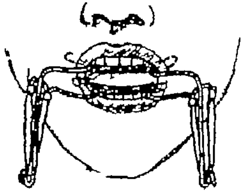


FIG. 813 Apparatus for relief of stiffness following removal of splint. Impression trays with lateral extension bars fitted to maxillary and mandibular teeth. Rubber bands stretched between bars for a few hours daily to exert traction to open jaws. (Ivy)

tion, the relief will be hastened by the institution of massage, the application of heat, and the exertion of interdental elastic force The latter may be obtained by stretching a rubber band between side bars soldered to impression trays fitted to the maxilla and mandible (57) (fig 813)

Management of Special Mandibular Fractures

For surgical purposes fractures of the mandible may be classified as follows

I *Fractures without Loss of Bone*

- A. Fracture of dentulous mandible
  - 1 Fracture of the horizontal ramus, in the region of
    - a. Symphysis
    - b Mental foramen
    - c. Molar region and angle
      - (1) Fractures behind the last existing molar or between the second and third molars

(2) Fractures between the premolar and first molar, or between the first and second molars, with a full complement of teeth in both jaws

(3) Fractures between the premolar and first molar, or between the first and second molars, with an edentulous posterior mandibular fragment

(4) Fractures between the premolar and first molar, or between the first and second molars, with teeth present in the mandibular fragment but absent in the opposing maxilla

2 Fracture of the vertical ramus

a Condyle and neck

b Coronoid process

B Fracture of edentulous mandible

II *Fractures with Loss of Bone*

Fracture of Symphysis

Fractures of the symphysis constitute only 8 or 9 per cent of mandibular fractures because of the thickness of the bone in this location The fracture may be single, double, or comminuted, and the treatment varies with each particular case Single fractures are usually vertical and lie between the central and lateral incisor teeth or between the lateral incisor and canine, only rarely do they occur between the two central incisors There is little displacement of the fragments, inasmuch as the muscular force is equally balanced on both sides In double fractures the anterior segment is lowered by the depressor muscles of the mandible, namely the digastric, geniohyoid, and geniohyoglossus, and the lateral fragments are elevated by the muscles of mastication, namely the temporal, masseter, and internal pterygoid In comminuted fractures with a loss of bone substance the two halves of the mandible are drawn toward the median line by the pull of the mylohyoid muscle, the lower dental arch being forced to lie within the line of the upper Obviously, if union is allowed to take place in this position, the ability to masticate will be lost

In single fractures intermaxillary wiring is usually sufficient to secure immobilization, but occasionally supplementary measures must be resorted to Blair (13) advises a low bone "wiring" with prepared tendon or silver wire through a transverse incision made beneath the lower border of the mandible

Double fractures, if seen early, may be reduced and immobilized by intermaxillary wiring of the teeth, and, in the case of an edentulous jaw, by circumferential wiring over a vulcanite denture (fig 812) If the fracture comes under observation late and the displacement is backward, forward traction can be obtained, as suggested by Blair (13), from a forward extension bar on an upper dental splint, or a counterweight working on a pulley fixed to bed or ceiling (fig 811-a) Or two holes may be drilled in the bone and through these holes wires passed and attached to an outrigger embedded in a plaster head-cap (fig 811-b) Immobilization is best maintained with the jaws in the open-bite position, as this relaxes the pull of the depressor muscles of the mandible (fig 814)

Comminuted fractures seen early can usually be reduced and maintained in position if the lower jaw is secured to the upper by means of an arch bar, but when observed late, especially if there is considerable overriding of the fragments, reduction is best

accomplished by the following method advocated by Schellhorn (102) Separate arch bars are applied to each mandibular fragment, the anterior ends of the bars being left long enough to overlap each other and be bent in the form of a hook A rubber band is stretched between the two hooked ends in such a manner as to exert force on the fragments in a direction away from the median line. This band is left in place until the displacement has been overcome (fig 815) After full reduction immobilization is maintained either by intermaxillary wiring or by means of cap-splints attached to the teeth If there has been a loss of bone, the space is spanned by a rigid bar connected to cap-splints on the teeth of each fragment.

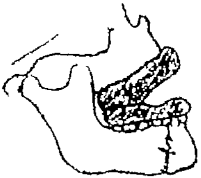


FIG. 814. Immobilization with jaws in open bite, to relax downward and backward pull of mandibulohyoid muscles—used in fractures about symphysis. Two gutter-shaped casts of light metal or vulcanite fitted over maxillary and mandibular dental arch. (Blair)

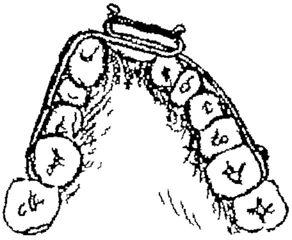


FIG. 815. Reduction of overriding comminuted fracture of symphysis. Separate arch bars applied to each mandibular fragment. Anterior ends left long enough to overlap. Rubber band stretched between hooks, to exert force away from median line. After reduction fragments immobilized with intermaxillary wiring of teeth. (Ivy and Curtis)

Fracture in Region of Mental Foramen

Fractures in the region of the mental foramen constitute about 30 per cent of all mandibular fractures, owing to the weakness of the bone in this region. The short posterior fragment is drawn upward and held in occlusion with the teeth of the upper jaw by the pull of the temporal, masseter, and internal pterygoid muscles. In the absence of teeth either in the upper or lower jaw the elevation is accentuated, as there are no teeth to prevent its ascent. The long anterior fragment, on the other hand is pulled downward and backward by the mandibulohyoid group of muscles In severe cases the fragments may overlap causing a deviation of the chin to the fractured side.

The line of fracture is usually oblique, running forward and upward These fractures may be reduced and immobilized by intermaxillary wiring (p 1208).

Fracture in Molar Region and Angle

Fractures in the molar region and angle constitute about 53 per cent of all mandibular fractures They may occur between the premolar and the first molar tooth, between the molars, or distal to them The displacement is similar to that which occurs in fractures of the mental region, the short posterior fragment being drawn upward by the muscles of mastication until it meets the opposing maxilla, and the long fragment slewing over to the injured side The treatment will depend upon the length of the posterior fragment and upon the presence or absence of teeth in the fragments and in the opposing maxilla

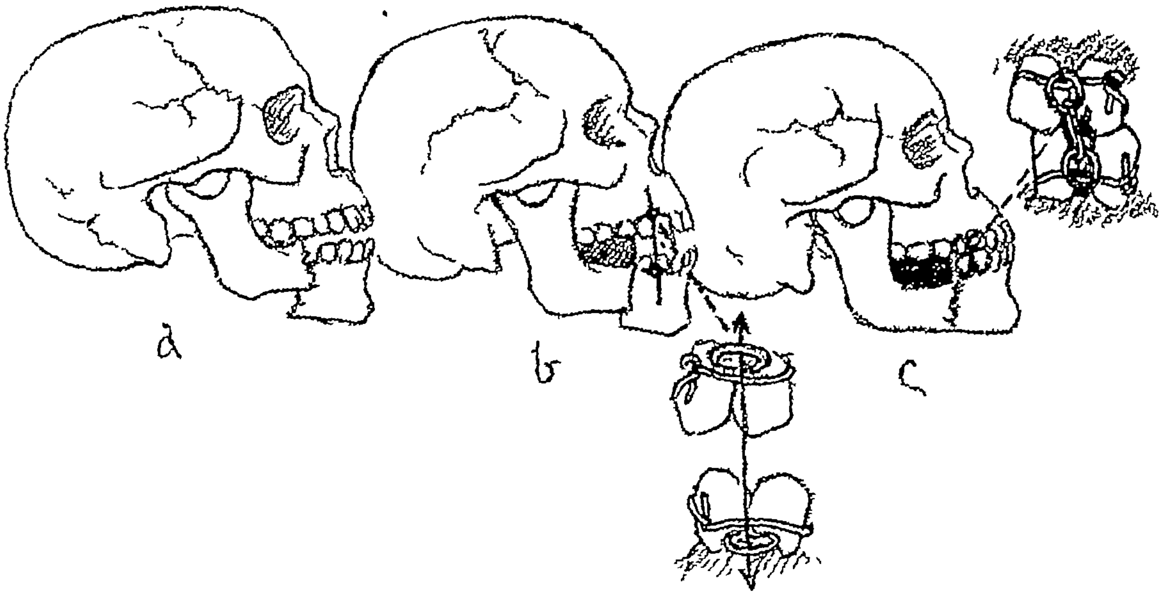


FIG 816 Immobilization of fractured mandible with edentulous posterior fragment. *a*, posterior fragment drawn upward by muscles of mastication, until it impinges on opposing teeth of maxilla *b*, posterior fragment held down by block of stent *c*, anterior fragment immobilized by interdental wiring Inserts show method of passing and tightening wires (Ivy)

If the fracture is *behind the last existing molar*, or *between the second and third molars*, the displacement will be slight, as the bone is well splinted by the masseter and internal pterygoid muscles, hence the usual intermaxillary wiring or dental cast fixation is sufficient The slight malalinement of the fragments will create no difficulty in mastication and the minor deformity resulting from the flattening of the angle can later be camouflaged with a fascia or cartilage graft

If the fracture is located *between the premolar and first molar* or *between the first and second molars*, intermaxillary wiring or fixation by means of cap-splints will furnish the necessary immobilization, provided there is a full complement of teeth in both jaws If the posterior mandibular fragment is edentulous, the elevator muscles will draw it upward until it impinges on the opposing teeth of the maxilla (fig 816) If the parts are left in this position, union is apt to be interfered with, owing to the small margin of contact between the fragments, and even should healing take place, the range of motion will be greatly restricted With an edentulous fragment the difficulty lies not

in the reduction of the fragment but in its maintenance in the proper relationship Inasmuch as there are no teeth to serve as points of anchorage, other means of immobilization must be sought. Many intra-oral fixation devices, such as saddles and intermaxillary blocks fastened to dentures for the purpose of holding down the edentulous fragment, have been suggested (fig 817), but experience has shown that the pressure of these appliances causes marked irritation and necrosis of the soft tissues.

The most practical method of immobilization is Ivy's modification of Darcissac's original method for double fracture (76) The technic is as follows (fig 818) Through a small skin incision the angle of the jaw on the affected side is exposed, and a hole is drilled through it well behind the fracture line Through this aperture a #24 gauge wire is passed and connected by means of a strong elastic band to a hook on a rod extending from the back of a plaster head-cap, in such a manner that backward and downward traction will be exerted on the posterior fragment. The wire is allowed to remain in place for several weeks and usually produces no irritation Wassmund (112) used a broad leather neck band for anchorage of the wire instead of a plaster head cap Kazanjian (68) cements to the teeth of the long anterior fragment a splint

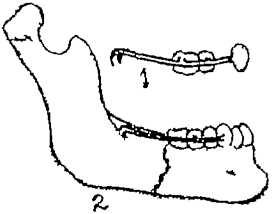


FIG. 817 Immobilization of fractured mandible with edentulous posterior fragment. Intra-oral splint cemented to teeth of anterior fragment and equipped with extension prong to hold posterior edentulous fragment in proper relationship (Kazanjian)

equipped with an extension prong designed to hold the posterior fragment in position (fig 817) Irrespective of the method employed to immobilize the posterior fragment, the larger anterior fragment is fixed to the upper teeth in the usual manner

A convenient method of constructing a plaster head-cap for the support of the embedded rod is that suggested by Scogin (106), as follows (fig 819) "(1) Seat patient in straight backed chair without head rest Have sufficient space so that operator may pass entirely around patient. (2) Drape patient well with sheet and towels to protect clothing from plaster (3) Clip hair on men if the case is to require lengthy fixation (two or more months)—otherwise not considered necessary Have women braid hair and arrange in loose coils on top of head (4) Apply one end of stockinette over head to a point two inches below previously determined border outline of finished headcap (5) Tie cord or tape loosely around stockinette at top of head so that the loop will be about two inches in diameter (6) Cut small slit in stockinette and push tied ends of cord through to inside. This is done so that stockinette may be tightened during later treatment if necessary (7) Cut and adjust felt strips, one (or more) in each quadrant, tape into place on stockinette. (8) Pull free end of

stockinette down over head and trim just short of the length of the first layer Felt strips are now between layers of stockinette There is a small opening at top of head in which the ends of the cord are found (9) Apply first plaster bandage Wet bandage in lukewarm water (hand basin held conveniently by assistant), and apply as a head bandage, keep bandage wet, and smooth into place with wet hands and a piece of sponge being certain to obtain desired outline form (10) Apply plaster wash over this layer, smoothing well with wet hands (11) Turn up both ends of stockinette to form the lower border of cap, plastering the stockinette into plaster wash (12) Insert traction

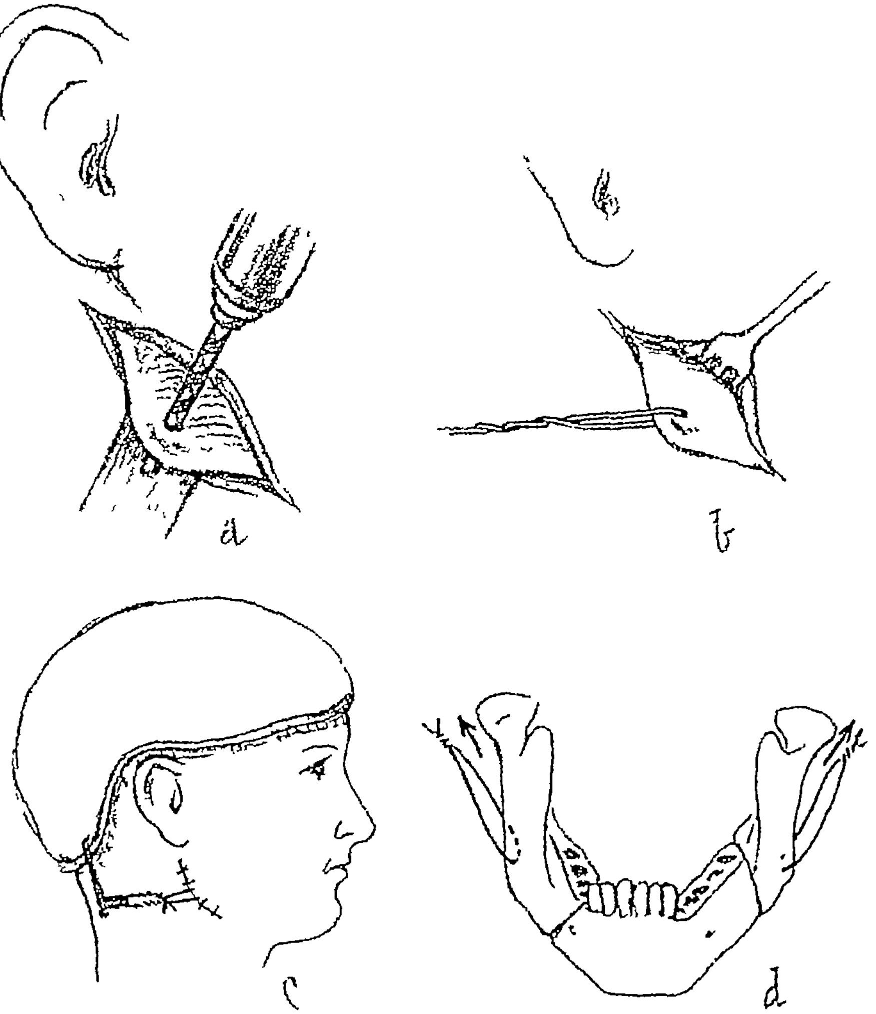


FIG 818 Immobilization of fractured mandible with posterior edentulous fragment *a*, angle of jaw on affected side exposed, and hole drilled in bone well behind fracture line *b*, strand of #24 gauge wire passed through drill hole *c*, wire connected by elastic band to hook on plaster headgear, to cause downward and backward traction *d*, diagram, showing direction of pull (Ivy)

appliances so placed as to deliver the correct directional force for the individual case ." A wire rod of the same thickness as a coat hanger is embedded in such a manner that it will project downward and backward, ending in a hook "(13) Apply second plaster bandage in same manner as before, except that the lower one-half inch of stockinette is left exposed, to produce a smooth, rounded border that will not cause irritation or crack during extended usage (14) Apply second plaster wash—smooth well with wet hands (15) Allow to dry four hours (on head, do not remove) then varnish with sandarac or any similar material to facilitate future cleaning "

Fracture of Vertical Ramus

The ramus of the mandible is well splinted and protected on its outer aspect by the masseter muscle and on its inner surface by the internal pterygoid Because of this protection fractures of this part of the bone are uncommon, and when they do occur there is little displacement of the fragments. The usual methods of intermaxillary

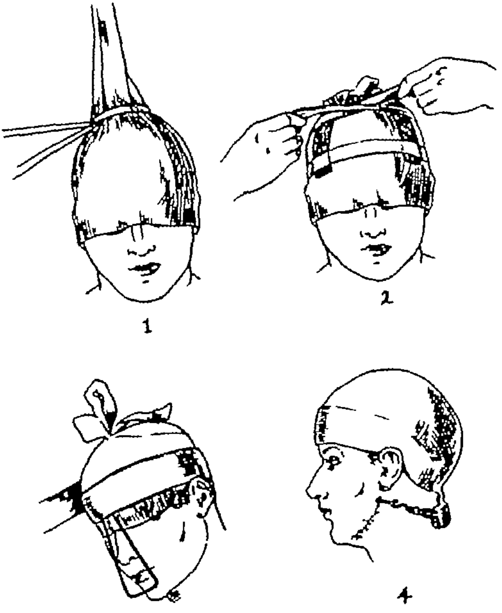


FIG. 819 Convenient method of constructing plaster head-cap For details, see text. (Scogin)

fixation by means of wires or cap-splints are sufficient to immobilize the fragments until union has taken place

Fractures of the condyle and neck constitute about 7 to 8 per cent of mandibular fractures. As a rule they are caused by indirect force applied to the opposite side of the chin. A common example is that which results from striking the chin on the steering wheel of an automobile in a head-on collision These fractures may be oblique, horizontal, or vertical, and usually encroach upon the sigmoid notch They vary in

extent from a fissure to a complete separation of the condyle The displacement is most commonly upward and inward, owing to the pull of the external pterygoid muscle attached to the base of the condyle In rare instances it is displaced outward In any case, the ramus is drawn upward by the masseter and temporal muscles, thus diminishing the space between the upper and lower teeth Because of the shortening on the affected side the chin deviates in that direction, and the angle of the jaw tends to become flat

There is a difference of opinion in regard to the proper management Some surgeons, fearing ankylosis if the condition is left untreated (108), advise fixation or removal of the condyle by means of an open operation, but these procedures seem unjustifiable Experience has shown that the danger of ankylosis is slight, and an open operation entails the risk of injury to the facial nerve lying just outside, and the internal maxillary artery situated just behind, the condyle Some attempt the construction of a false joint, the mandible being immobilized for 5 to 7 days, after which time the patient is encouraged to move the jaw To prevent the mandible from swinging to the affected side, a splint with an inclined plane is worn (p 1212) for 4 to 5 weeks thereafter (116) The weight of opinion favors treatment of condylar fractures by ordinary intermaxillary fixation for 3 to 5 weeks Shortening on the affected side is overcome by means of a piece of gutta-percha or stent interposed between the opposing molar teeth before they are fastened in occlusion (62) (fig 816) Should the condyle be displaced outward and cause deformity, it may be resected at a later date

The *coronoid process* is the part least commonly fractured, as it is deeply situated and well protected by the zygoma When fracture does occur here, however, there is a tendency on the part of the coronoid process to be drawn upward by the temporal muscle, but this causes little deformity and only slight impairment of function The treatment comprises a short intermaxillary immobilization of 1 or 2 weeks, by which time the acute discomfort will have passed Movement is then encouraged as a precaution against the formation of adhesions

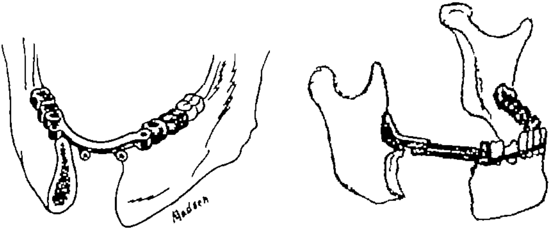
Fracture of Edentulous Mandible

In an edentulous mandible a precise reduction of the fracture is not essential, provided the displacement is slight, since any deficiency of alinement after union can be compensated for by an artificial denture Immobilization, however, is necessary to obtain union Adequate fixation can usually be secured by wiring together the patient's upper and lower artificial dentures, supplemented by the application of external pressure by means of an elastic bandage If there is marked displacement of the fragments, circumferential wiring around the denture must be resorted to

Fracture with Loss of Bone

In mandibular fractures involving a loss of more than 1 5 cm of bone no attempt at direct approximation of the fragments should be made, since this would result in a narrowing of the arch, malocclusion, and marked deformity of the jaw The arch can be restored to its normal length only by the addition of new bone in the form of an autogenous bone graft (The only exception to this rule is in the case of aged individuals with edentulous jaws Here, since malocclusion is of little consequence, direct ap-

proximation is indicated, provided the loss is moderate) Until conditions become favorable for reconstruction, the fragments must be fixed in their normal relationships to prevent their displacement by the unopposed action of the muscles and contraction of the surrounding scar tissue The method of fixation will depend upon the size and location of the defect and the number and disposition of the teeth If teeth exist in each fragment, they are covered with metal cap-splints, to which a crossbar is cemented to bridge the defect (fig 820) If the soft parts are lacerated, a vulcanite flange may be attached to the splint to maintain the sulcus The technic of correcting the



a b

FIG. 820 Splints designed to prevent displacement of fragments and distortion of soft tissues, following mandibular fractures associated with loss of bone. *a* teeth fitted with metal cap-splint carrying crossbar to bridge defect, and equipped with holes for reception of flange to maintain gingivolabial sulcus—applicable when teeth exist in both fragments (Rosenthal) *b* splint equipped with saddle to push ramus down and back, and screw attachment to gradually force separation between fragments—applicable when posterior fragment is edentulous (Herpin)

loss by means of a bone graft is described in the section dealing with reconstruction of the jaw

COMPLICATIONS OF MANDIBULAR FRACTURES

Infection

Infection is the most frequent complication of mandibular fractures and has been variously computed to occur in from 10 to 40 per cent of all cases It is due to the presence of foreign bodies and septic teeth and to the close relationship between the jaw and the oral cavity The infection may be limited to the soft parts or involve the bone as well. It is ushered in by a rise of temperature soon followed by pain, swelling, redness, and induration of the parts In time liquefaction takes place, and the pus either finds its way into the mouth or opens on the cheek or in the submaxillary triangle above or below the geniohyoid muscle leaving fistulous tracts.

The general management of infection is detailed on page 505 If the process originates in the vicinity of a tooth near the fracture line the intermaxillary tie wires are cut, the tooth extracted and the wires replaced If suppuration develops, drainage must be instituted. Occasionally, the infected area is so situated that an intra-oral incision may be used for the purpose but more frequently it will be found necessary to resort to an external incision which must be so planned as to secure drainage at the most

dependent point, and at the same time leave an inconspicuous scar Generally, the most appropriate and convenient site is just below and parallel to the mandible, either in front or behind the facial vessels, but when the pus is situated along the ascending ramus, it may be more readily evacuated through an incision beneath the angle of the mandible In cases of extensive suppuration through-and-through drainage may be expedient, the tube being carried beneath the parotid gland, lest it cause damage to the facial nerve and parotid duct

If the bone itself is involved, the weight of surgical opinion favors conservative treatment During the acute stage operative intervention is contraindicated, since chiseling of the diseased bone will interfere with osteogenesis, endanger the nutrient arteries, and predispose to non-union It is better to wait for natural sequestration In the meantime, antiseptic irrigation and drainage are instituted (p 987) Blair (13) warns against instrumental manipulation of the bone before the infection has lost its virulence, as this may lead to further extension of the infective process After a sufficient involucrum has formed—a process which usually requires about three months—the sequestrum is exposed through an incision along the alveolar process, the lower border of the mandible, or along the posterior margin of the ramus, depending upon its location, and removed with a chisel or a curet, care being taken to avoid injury to the involucrum In case the sequestrum is buried in the involucrum, however, a part of the latter may have to be chiseled away before the sequestrum can be extracted

Delayed Union

Delayed union is a frequent complication of mandibular fractures It has been variously attributed to both general and local conditions (74) Among the general causes stressed are advanced age, debility, syphilis, rickets, osteomyelitis, a deficiency in the concentration of the inorganic bone-forming elements in the blood, and endocrine dysfunction (84) The majority of surgeons minimize the importance of systemic factors and stress the local causes—notably, the interposition between the fragments of soft parts or foreign bodies such as sequestra, infected teeth, loose fragments of bone, or hematomata, faulty or late reduction, infection, unnecessary manipulation; and inadequate or excessively rigid immobilization Contributing causes are injury to the blood vessels, laceration and loosening of the periosteum from the bone, and infection

Treatment is directed to improvement of general health and the removal of the local cause All foci of infection must be eliminated, and interposed soft parts and foreign bodies, such as sequestra and teeth in the line of fracture, removed Various methods have been suggested to stimulate osteogenesis, such as intermittent compression of the facial artery, massage, percussion of the bone at the seat of fracture, and provision for some degree of movement in the splint for the purpose of irritating the ends of the fragments If despite these measures the bone fails to unite after 6 months, the condition may be considered as one of non-union

Non-Union

Non-union is the result of a total cessation in the reparative process and is a rare complication of mandibular fractures It may be (1) primary, due to a lack of contact

between the fragments, arising from (a) the interposition of soft or hard tissue which cannot be penetrated by the osteoblastic tissue, (b) overriding of the fragments, (c) a separation of the fractured ends too extensive to be bridged over or (2) secondary to delayed union and resulting from the same causes. Anatomically, non-union is considered to be established when potential proliferation has ceased, the bone canals have closed, the intervening granulation tissue has been converted into a dense scar, and the ends of the bone eburnated, and clinically when careful treatment over a period of 6 months has proven unsuccessful.

The treatment is essentially that prescribed for non union elsewhere in the body and is directed toward the removal of the causative factor The line of fracture must be opened, the interposed ischemic scar tissue and the cicatrix in the neighboring soft tissue removed, the ends of the bone revivified, splinted in good position, and treated as a recent fracture. In the case of an extensive destruction of bone the loss must be replaced with a graft.

Malunion

Malunion following mandibular fractures results in interference with dental occlusion and asymmetry of the face, and may be caused by an unopposed muscular pull on the fragments, improper reduction, incorrect fixation, contraction of scar tissue, or an attempt to obtain union in cases involving a considerable loss of bone. It is especially common following fractures in the molar region in the presence of a posterior edentulous fragment.

If the patient is seen early before ossification has taken place the fragments may be realined by gradual elastic traction (p 1210) If ossification is already complete, however and the occlusion is satisfactory, no treatment is required. The slight facial deformity occasioned by the flat angle can be corrected by means of a fascia or cartilage graft (p 182) But if the malunion interferes with normal function, an osteotomy must be performed and the fragments reset in their proper relations and immobilized. Before the osteotomy is undertaken, the exact location for the division of the bone is outlined on a plaster work model and a splint constructed to immobilize the bones following their repositioning In some cases it will be found convenient to make the splints in sections, cement them to the teeth prior to operation, and lock them in position after the osteotomy The bone is exposed through an incision 1 to 2 cm in length made along the lower border of the mandible at the site of the proposed osteotomy The bone may be divided with a chisel or a gigh saw In the latter case a trocar and cannula is introduced close to the bone on the lingual side and made to appear in the mouth (fig 821) The trocar is withdrawn and the saw passed through the cannula until it projects into the oral cavity after which the cannula is removed. Handles are then attached to the saw, and the bone is separated. The skin incision is closed without drainage. If no bone has been lost, the fragments are reduced and immobilized in the same manner as in a recent fracture If considerable bone has been destroyed, however, the fragments are held in the proper position by means of cap-splints applied to the teeth in both fragments and spanned by a rigid bar This appliance is left in place until conditions become favorable for bone-grafting

If the site of malunion lies at the head or neck of the condyle and has resulted in an open denture, the head of the condyle may be resected, or an osteotomy may be per

structed for purposes of study. De Coster (28) estimates the extent of the deformity by the use of charts, as follows (fig 823): "We establish normal schemas with a trace of the lines which correspond to the line of normality of the face in every way There exists a normal schema for each stage of growth We take the normal schema appropriate to the age of our patient The lines of the normal mesh, forming on our standard schema several rectangles embracing the interesting anatomic points of the face, acquire a given relationship with these points Either on our abnormal schema or directly on the radiograph we apply the lines of the mesh in such a way as to trace a

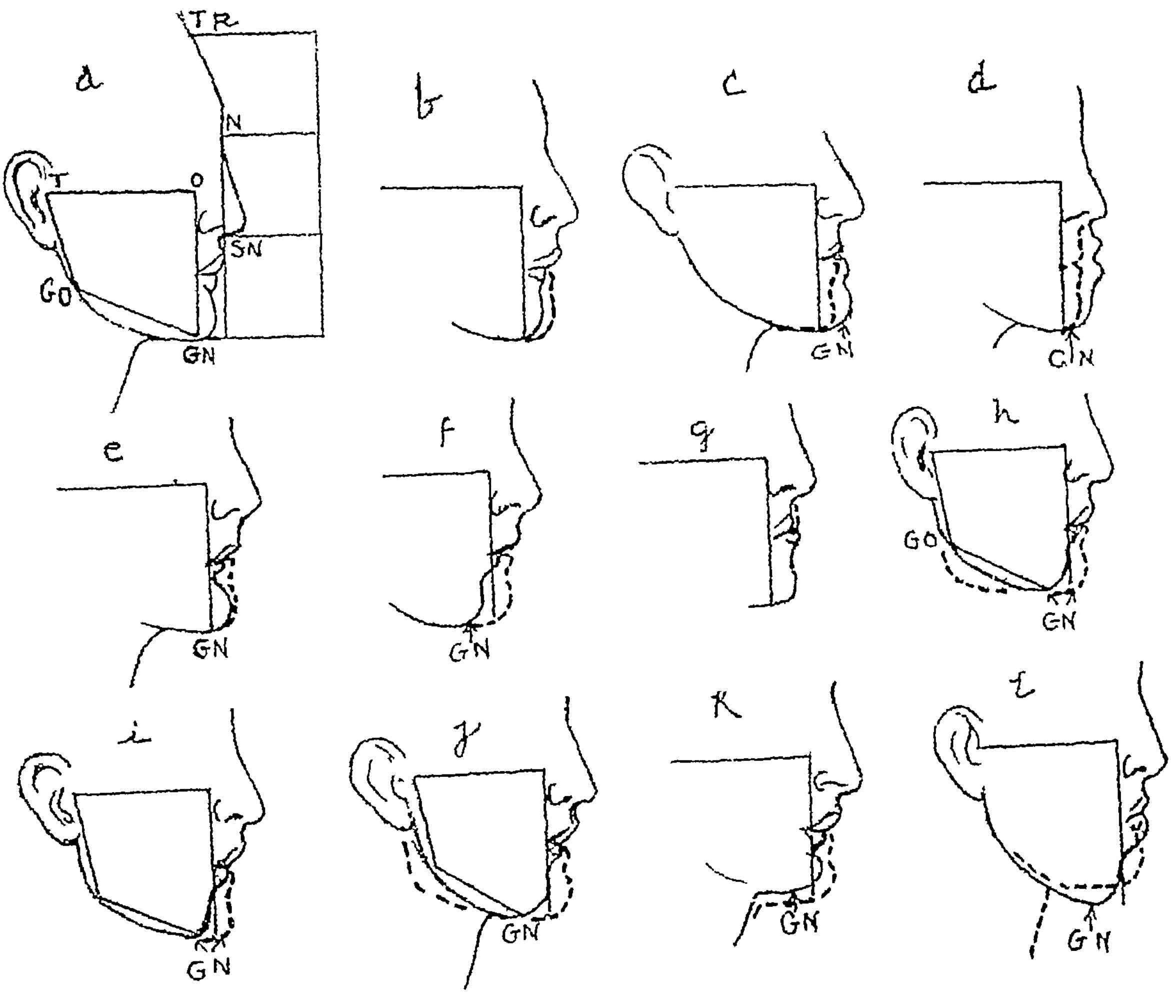


FIG 824 Scheme of sagittal deviations, as shown by photo-gnatho-static reproduction *a*, normal denture, *b*, maxillary protraction, *c*, mandibular protraction, *d*, bimaxillary protraction, *e*, lower alveolar retraction, *f*, mandibular retraction, *g*, maxillary retraction, *h*, vertical mandibular retraction, *i*, horizontal mandibular retraction, *j*, total mandibular protraction, *k*, mandibular attraction, *l*, mandibular abstraction (Hensel)

meshwork about the anatomic points, presenting the same relations as in normal mesh. To safeguard these relations it is often necessary to deform the lines of the mesh These deformations express the difference between the relative situation of the normal and the abnormal points and so express the deformity " Figure 824 illustrates various forms of maxillary and mandibular abnormalities

PROGNATHISM

Prognathism is a deformity characterized by an abnormal protrusion of the mandible, the broad posterior part of the lower dental arch lying opposite the anterior narrow

portion of the upper arch and the lower first molars occluding with the upper bicuspids. The lower incisors project 1 to 2 cm beyond the upper and are turned either inward or outward, depending upon whether the lips are kept open or closed. Due to the impact of mastication on the lingual cusps of the lower molars, they are tilted toward the tongue, and for the same reason the body of the mandible is rotated outward. The angles of the jaw are obtuse and flattened, and the mental process is hypertrophied. The maxilla is usually underdeveloped, probably because the tongue, finding too much room in the lower dental arch, fails to exert pressure on the upper arch. The lower lip is enlarged and pendulous Altogether the patient presents a most displeasing appearance. In marked types of the deformity there is also an interference with mastication and phonation, due to the inability of the lips and cheeks to function properly

Mandibular prognathism may be due to an actual hypertrophy of the bone or to errors in the eruption of the teeth According to Angle (3) premature removal of the

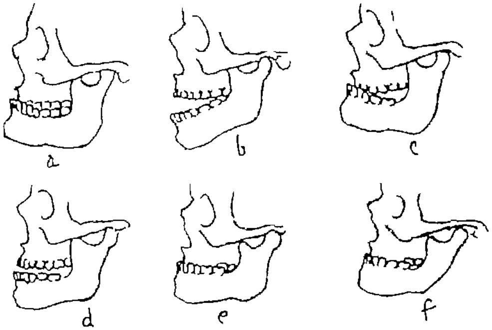


FIG 825. Types of prognathism. *a*, molar contact with incisive supraclusion *b*, molar contact with incisive infraclusion, *c*, molar infraclusion and incisive supraclusion, *d*, generalized infraclusion *e*, generalized supraclusion *f* molar contact with otherwise general supraclusion. (Modified from Hensel)

deciduous molars may be the initiating factor As a result of the extraction, the permanent molars erupt in an abnormal medialward location causing the balance of the permanent teeth to appear in front of the abnormally placed molars and thus gradually forcing the jaw forward. Other causes are forward displacement of the mandible consequent upon fractures and dislocations and contracting scars about the face, neck, and chin. The condition is often simulated by a disparity between the upper and lower jaws due to a recession of the maxilla

The character of the bony deformity varies widely Hensel (53) classifies mandibular deviations according to the viewpoint of Landals (75), as follows (fig 825)

1 Mandibular Prognathism
   a With molar contact and incisive supraclusion
   b With molar contact and incisive infraclusion
   c. With molar infraclusion and incisive supraclusion
   d. With generalized infraclusion
   e. With generalized supraclusion

2 Obtuse Mandible Without Prognathism
 Molar contact and generalized infraclusion otherwise
3 Mandibular Laterognathism
 a With molar infraclusion and incisive supraclusion
 b With molar contact and incisive infraclusion

TREATMENT

The treatment consists in a combination of orthodontic, surgical, and prosthetic measures

Orthodontic Treatment

Orthodontic treatment aims at the alteration of the lower dental arch, with a view to improving the occlusion and at the same time correcting the facial asymmetry The principle of the procedure is to subject the teeth to pressure and tension stresses which will be transmitted to the bony structures in such a manner as gradually to force the teeth into occlusion and eventually reshape the jaw This may be accomplished by stretching rubber bands between the anterior mandibular and the posterior maxillary teeth or by gradually shifting individual teeth by means of wires, gliding splints, and inclined planes Such treatment may be all that is necessary when the anomaly lies in the dental arch and the patient is seen early in life, while the bone is still pliable But in severe cases or in those seen in individuals beyond 16 years of age, when the bone is no longer pliable, or where the anomaly lies outside the dental arch, surgical treatment must be resorted to Angle (3) stated that under such circumstances "any orthodontic procedure is powerless to render improvement, and the double resection is the only resort "

Surgical Treatment

The pioneer in the attempt at surgical correction of this deformity was Hullihen (54) who in 1849 performed a partial osteoplastic resection of the jaw Angle (2) in 1898 advised a complete bilateral resection of the body Blair (12) (1907) resected a quadrilateral section of bone from either side of the body and was the first to elaborate a practical technic for the relief of the condition Various types of intra- and extra-oral operations have since been performed both on the ramus and on the body, as illustrated in Figure 826

Choice of Method

Repositioning may be accomplished by (1) *osteotomy*, or (2) *ostectomy*

(1) *Osteotomy* contemplates division of the ramus and shifting of the body of the bone backward to the desired position, followed by immobilization until ossification is complete Credit for the origin of this operation belongs to Blair (14) It is the method advocated by Babcock (8), Pichler (95), Kostečka (73), Bruhn (22), Padgett (91), and others It is the most desirable of the operative procedures It is simple in conception, entails no sacrifice of bone, causes no damage to the mandibular arch and its teeth, requires no opening into the oral cavity, and reduces to a minimum the

muscle traction which tends to counteract the reduction. But osteotomy of the ramus has certain obvious disadvantages. In the first place, there is danger of injury to the parotid gland, facial nerve, and internal maxillary artery, although with ordinary care this is usually preventable. Furthermore the backward displacement of the body may shorten the space behind the angle to such an extent that function will be interfered with. Finally, the procedure necessitates a prolonged period of intermaxillary fixation.

The osteotomy may be performed through *the neck of the condyle, the angle* or *the ramus*. Division of the neck is indicated only when the prognathism is due to a malunited fracture associated with forward displacement. Separation of the angle is

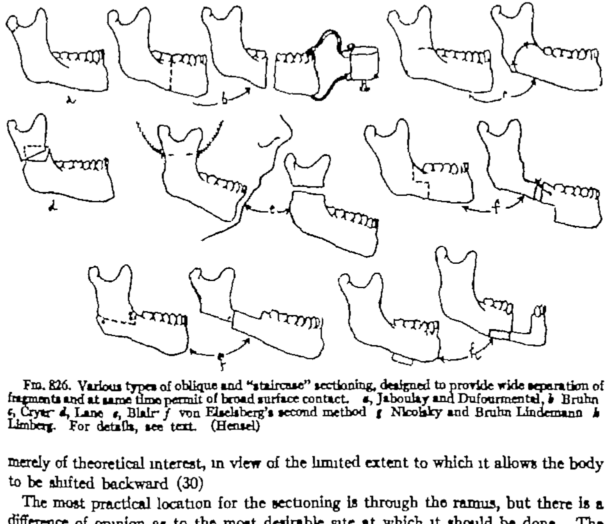


FIG. 826. Various types of oblique and "staircase" sectioning, designed to provide wide separation of fragments and at same time permit of broad surface contact. *a*, Jaboulay and Dufourmentel, *b* Bruhn *c*, Cryer *d*, Lane *e*, Blair *f* von Eiselsberg's second method *g* Nicolsky and Bruhn Lindemann *h* Limberg. For details, see text. (Hensel)

merely of theoretical interest, in view of the limited extent to which it allows the body to be shifted backward (30).

The most practical location for the sectioning is through the ramus, but there is a difference of opinion as to the most desirable site at which it should be done. The division can be made (a) between the incisura and the point where the inferior alveolar nerve and vessels enter the canal (fig 827). While an osteotomy in this region preserves the aforementioned vessels and nerves it carries the risk of injury to the parotid gland, internal maxillary artery, and facial nerve. Furthermore, there is a tendency on the part of the upper fragment to become displaced by the temporal and external pterygoid muscles and lead to a permanent closed or open bite. There is also the danger of a splintering of the upper portion of the ramus with a resultant separation of the coronoid from the condylar process. Hensel (53), who advocates this incision, points out important landmarks which will serve to protect the inferior alveolar nerve

and vessels from injury "The measured distance from the bottom of the mandibular notch to the lingula varies from seven-sixteenths to ten-sixteenths of an inch depending on the size and contour of the mandible The inferior alveolar nerve enters its foramen three-sixteenths of an inch or less below the spine of the lingula and is very close to the inner surface of the mandible for a similar distance above the lingula These measurements make evident the small margin of error permissible at the site of osteotomy Selecting a middle third of this measured distance, a safe osteotomy can be performed only within a field of three-sixteenths of an inch through the midlinear area (fig 827-b) . The area between the mandibular notch and lingula available for section will vary from 12 to 14 mm The width of the ascending ramus will approximate 40 mm at the level of section A rectangle of these dimensions may be constructed, and it will include the area of bone available for safe osteotomy. The

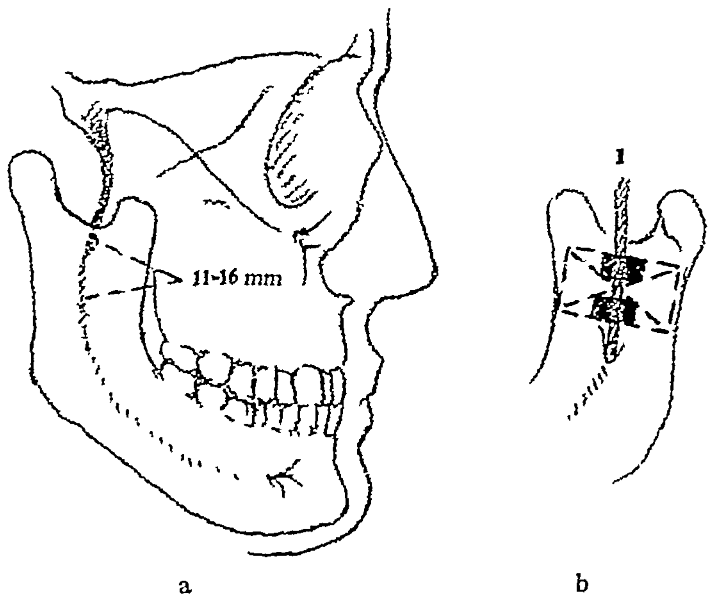


FIG 827 Site for osteotomy of ramus, to conserve inferior alveolar nerve. *a*, shows relation of inferior alveolar nerve to mandible Bone sectioned between incisura and lingula, providing available space of 11 to 16 mm *b*, internal view of ramus, showing field for osteotomy *1*, inferior alveolar nerve Shaded areas, unsafe for osteotomy, unshaded areas within dotted lines, safe for osteotomy. Maximum obtainable obliquity for sectioning, as indicated by dotted line, 20 degrees For details, see text (Hensel)

maximum obliquity obtainable will be illustrated by the division of this rectangle through its greatest dimension It will determine an angle of 20 degrees " (b) The osteotomy may be made through the ramus 1 cm above the occlusal surface of the inferior molars Here there is little risk of injury to important structures, but the inferior dental nerve and artery must necessarily be sacrificed

Irrespective of the site at which the osteotomy is to be performed, the direction of the line of sectioning is of the utmost importance and will be governed by the nature of the deformity If the ramus is too long, producing an inframolar separation with an incisive supraclusion, it must be shortened, and this is accomplished by an osteotomy directed downward and forward (fig 828-a) This permits of a posterior displacement of the body with shortening of the ramus (fig 828-b), but if the deformity is associated with an abnormally short ramus wherein the molar contact blocks incisive occlusion, the line of separation is carried upward and forward (fig 828-c, d) Where the jaw is

protracted forward with little change in the plane of angulation, the ramus is divided transversely

(2) Correction by *ostectomy* consists in the removal of a section of bone from either side of the mandible and the repositioning of the bone backward into the space thus created, so that the teeth will fall into normal occlusion The excision may be made at *the neck of the condyle* at *the angle* or in *the body* Resection of the condyle was first

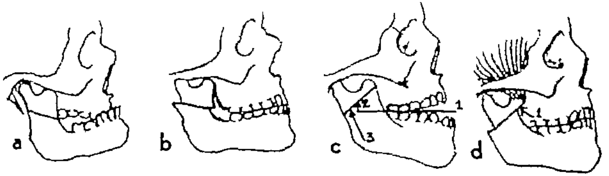
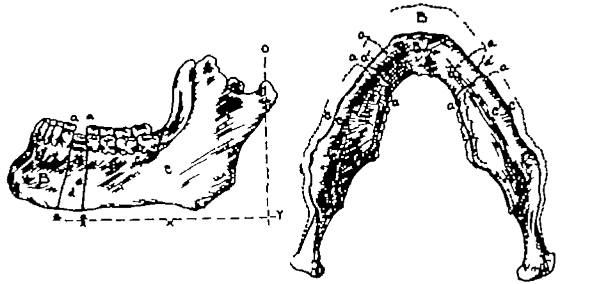


Fig. 828. Direction of osteotomy for correction of prognathism. *a* ramus too long, producing molar infraclusion with incisive supraclusion. Osteotomy directed downward and forward. *b* body shifted backward, to shorten ramus and obtain normal occlusion. *c* ramus too short, with molar contact blocking incisive occlusion. Line of osteotomy carried upward and forward. *d* body shifted backward to lengthen ramus and bring teeth into normal occlusion. (Modified from Hensel)

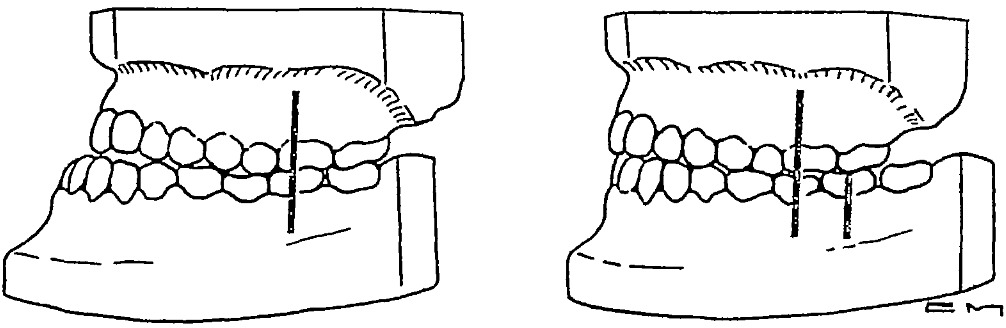


I II

Fig. 829 Ostectomy through body of mandible. *I* abnormally long jaw with interdental spaces in premolar region. Showing position of cuts for correction. *a–a*, saw-cuts *d*, section of bone to be removed, *e–y* axis of rotation *x–x*, distance from saw-cut to last molar *x–y* distance from last molar to axis of rotation. *B* anterior fragment. *C* posterior fragment. *II* reconstructed jaw showing how both forward and lateral protrusions are corrected by removing bone sections. Dotted lines indicate jaw bone shown in *I* (Blair and Ivy Essentials of Oral Surgery, 1936)

described by Jaboulay in 1898 and has since been advocated by Dufourmentel (35), who states that after this procedure it is possible to move the mandible backward from 1 to 2 cm. The objection to a resection in this location is the destruction of the temporomandibular articulation and the shortening of the ascending ramus which tends to aggravate the already faulty relationship of the anterior teeth. Ostectomy through the angle like osteotomy at this site is merely of theoretical interest

The most practical operation consists in the removal of a previously measured section of bone from either side of the body of the mandible, the result simulating a bilateral mandibular fracture associated with loss of tissue After the excision the anterior fragment is shifted backward to form a new arch and immobilized until union is complete (fig 829). There is some difference of opinion as to the most appropriate site for the resection Kazanjian (66) believes that the best location is in the region of the first molar or premolar, whereas Blair (14) takes advantage of natural or acquired dental spaces but favors the second molar area The operation, first devised by Blair in 1898, is favored by Schultz (104), Henschen and Schwarz (52), Pichler (94), Padgett (91), and Kazanjian (67) It has the advantage of accessibility, the fragments can be repositioned more satisfactorily, and a dental splint fitted to the mandible will often hold them in place without the need of intermaxillary wiring. The objections to the procedure, on the other hand, are that one or two teeth must be sacrificed if the required space does not already exist, the shifting of the mandible backward renders the third molar useless, and the mandibular nerve and vessels are necessarily injured Finally, the greatest drawback is the likelihood of opening into the oral cavity, with its associated danger of infection



a b

FIG 830 Estimation of amount of bone to be removed for correction of prognathism *a*, models of maxilla and mandible set up in articulator in existing malocclusion Perpendicular line drawn through second maxillary molar and continued onto mandibular model *b*, maxillary model carried forward, until teeth fall into proper occlusion Line on maxilla extended onto mandible Space between lines indicates amount of bone to be removed (Kazanjian)

Preoperative Measures

Before the operation is undertaken, the deformity should be studied on roentgenographic plates and plaster casts, in order that the proper site and direction of the saw-cuts may be accurately gauged If a section of bone is to be removed, models of the maxilla and mandible are set up in an articulator in the existing abnormal occlusion. A perpendicular line is drawn through the second maxillary molar and continued onto the mandibular model The maxillary model is then carried forward until the teeth fall into satisfactory occlusion, and the line previously made on it is extended vertically onto the mandibular model. The distance between the first and second lines on the latter model represents the amount of bone to be excised on each side (fig 830). Willet (113) determines the amount of bone to be removed and the proper angle of the resection by means of the formula shown in Figure 831.

Preoperative provision must be made for the immobilization of the fragments as

soon as they have been repositioned. As in the case of fractures, this may be accomplished (1) by intermaxillary wiring of the teeth (2) by upper and lower arch bars, or (3) by cast splints. If the latter are to be used, they are cemented to the teeth prior to operation and wired or locked together after repositioning If a resection is contemplated, the cast may be constructed in three parts and cemented to the teeth before the ostectomy, the parts of the mandible to be excised being left uncovered During the operative procedure the adjacent ends of the splints will serve as guides for the saw-cuts (14) Kazanjian (66) uses a retention splint fastened to the maxillary teeth and a mandibular splint in three sections (fig 832) Bands are fitted over

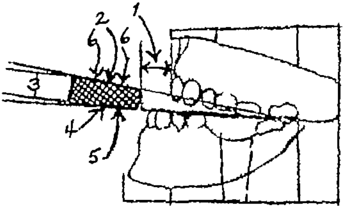


FIG. 831 Formula to determine amount and angle of resection *1* theoretical protrusion *2* pattern, *6*, upper occlusal plane *3* equal to protrusion *4* lower occlusal plane *5* angle of malocclusion (Willet)

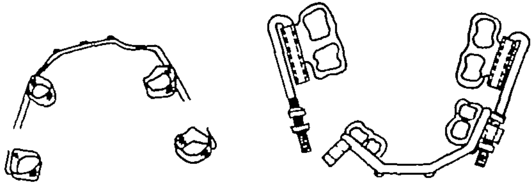


FIG. 832. Splint for immobilization of fragments after repositioning of bone. *a* retention splint, to be fastened to maxillary teeth. *b* mandibular splint in three sections For details, see text. (Kazanjian)

the posterior teeth and a round tube is soldered to the buccal surface At least two anterior teeth are utilized on each side and fastened together with a stout wire A vertical slot is soldered into the buccal side of these bands. After the operation the anterior and posterior bands are connected with a stout wire threaded on one end and hooked on the other ' He states that ' the advantage of this procedure is that it allows for a readjustment to new positions as healing of the parts progresses."

The operation may be performed under general or local anesthesia. If a general agent is preferred, it is administered endotracheally with the tube passed through the nose. Local anesthesia is obtained by blocking the mandibular division of the trifacial nerve and supplementary local infiltration. For the nerve blocking two needles

of equal length are employed, the first one serving as a guide for the second which is to deliver the solution One needle is introduced below the middle of the zygomatic arch and advanced to a depth of 4 to 5 cm, until it strikes the pterygoid process (fig 833) At this point it will be about 0 5 to 1 cm from the foramen ovale The second needle is then made to enter the skin at a point 1 cm behind the first and to probe its way into the foramen ovale. If the length of the visible portion of the two needles is compared from time to time, the danger of undue penetration into the cranial cavity can be avoided When the needle is in the proper position, 10 cc of a 2 per cent solution of procain adrenalin are introduced into the foramen ovale As the instrument is withdrawn, another 10 cc. are injected in the region of the incisura mandibulae

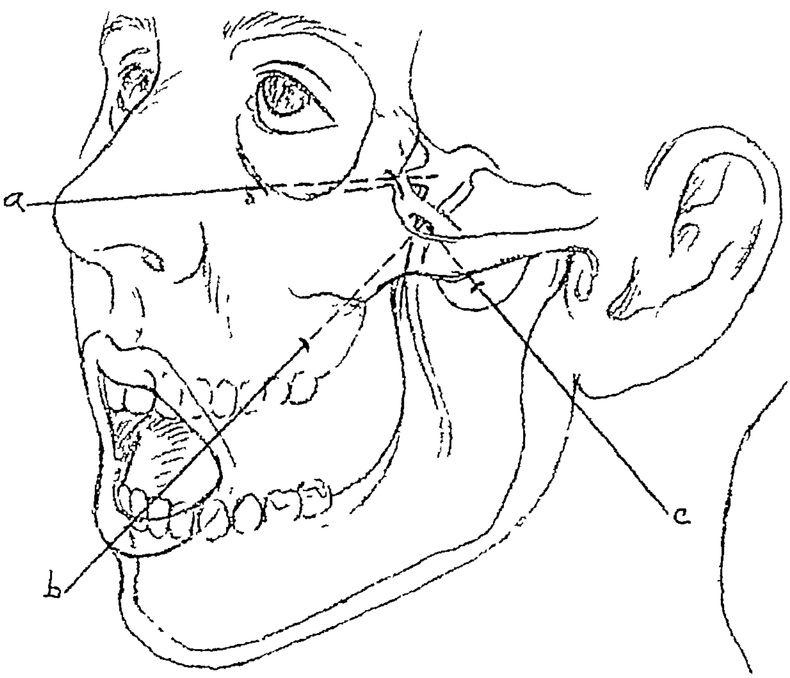


FIG 833 Various methods of approach to block mandibular nerve *a*, Matas' method, *b*, intra-oral approach, *c*, zygomatic route

Technic of Osteotomy

The osteotomy may be performed through a more or less circular incision within the concha circumscribing the acoustic meatus, the bone being exposed by folding forward the auricle (4, 5, 6) (fig 854) This incision eliminates the danger of injury to the facial nerve, the residuary scar will be imperceptible, and bleeding can be more easily controlled than in the usual incision which passes in front of the ear along the posterior border of the ramus (fig 834) The soft tissues are retracted until the zygomatic arch and articular tubercle are exposed The parotid fascia is divided, and the upper pole of the gland is separated from the capsular ligament and from the ramus The gland, together with the branches of the facial nerve, is then drawn forward and downward The periosteum on the posterior margin of the ramus is incised and elevated from the outer aspect of the bone That on the inner surface is then carefully separated, great care being taken to avoid penetration into the oral cavity Should such an accident occur, it will probably be best to close the wound and postpone further operation until all danger of infection has been eliminated Blair believes, however, that the danger of infection under these circumstances has been overem

phasized, and in proof calls attention to the fact that although practically all mandibular fractures are compound they unite nearly as readily as do simple fractures.

After the bone has been exposed, the ramus is divided 7 to 8 mm. below the incisura, the line of the osteotomy being transverse or oblique, depending upon the nature of the deformity (p 1233) Division may be accomplished with a gigli saw (fig 842), a blunt end straight saw, or a chisel. If the latter instrument is used, a nick is made in the bone and gradually deepened until the ramus is completely divided (fig 834) As a precaution against injury to the internal maxillary artery which lies just behind the ramus, a curved metal spatula may be applied to the inner aspect of the ramus before the sectioning is begun The same procedure is carried out on the opposite side. When both rami have been osteotomized, the jaw will sink downward and backward as in a bilateral condyloid fracture. It is then repositioned and immobilized, and the ear is sutured back into place.

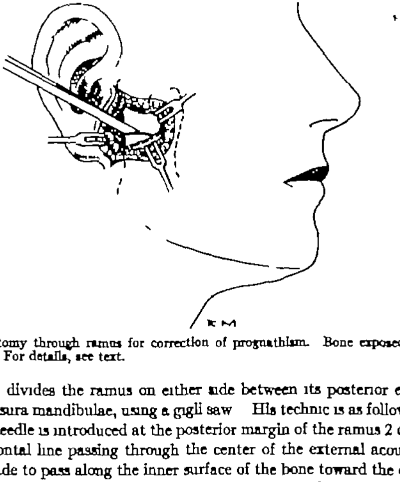


FIG. 834. Osteotomy through ramus for correction of prognathism. Bone exposed through preauricular incision. For details, see text.

Kostečka (72) divides the ramus on either side between its posterior edge and the center of the incisura mandibulae, using a gigli saw His technic is as follows (fig 849) A curved Blair needle is introduced at the posterior margin of the ramus 2 cm below an imaginary horizontal line passing through the center of the external acoustic meatus. The needle is made to pass along the inner surface of the bone toward the center of the incisura mandibulae, at which point it is brought out through the skin. The saw is then attached to the needle, and the latter is withdrawn, carrying the saw with it. Handles are attached, and the bone is cut through The same manoeuver is now repeated on the opposite side The jaw is repositioned and immobilized for about 12 weeks, for the first 3 weeks by means of a dental splint, and thereafter with elastic bands so placed as to exert traction on the mandible in a backward direction. An orthodontic cap is worn at night to hold the jaws together

Ernst (39) cuts the ramus from within the oral cavity and for this operation he has devised a special instrumentarium. With the mouth held wide open, the coronoid

process is located by palpation, and an incision is made over it to expose the ramus The periosteum is then elevated and the bone sectioned in the usual manner While this method leaves no external scar and eliminates the danger of injury to the facial nerve, these advantages are outweighed by the likelihood of infection

Hensel (53), in an effort to secure a more certain line of osteotomy, employs a direct surgical approach to the ramus (fig 835) A horizontal incision 3 5 cm long and carried through the skin and subcutaneous tissue is made across the cheek on a level with the lobule of the ear At a point 0 9 cm anterior to the lobule, it is curved sharply downward and forward along the posterior border of the mandible for an additional 3 5 cm The convex flap thus outlined is turned down until the anterior border of the parotid gland is identified The gland, with its capsule intact, is separated from its attachments for a distance sufficient to permit of its displacement upward and backward to expose the masseter muscle, which is next split in the direction of its fibers and drawn back The periosteum of the outer wall of the ramus is incised and retracted to expose the incisura and the anterior and posterior borders of the ramus An osteotomy is performed 7 to 8 mm below the center of the mandibular notch, the obliquity depending upon the nature of the deformity

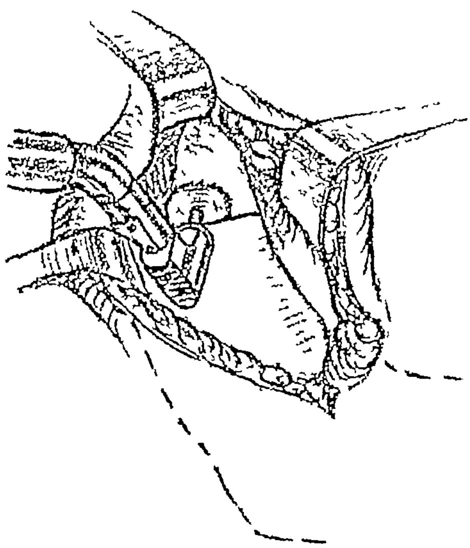


FIG 835 Osteotomy through ramus performed with separating saw $\frac{9}{16}$ inch in diameter driven by dental motor For details, see text (Hensel)

To divide the bone Hensel (53) uses "a dental motor fitted with a cable drive and contraangle attachment into which a carrier shaft and separating saw nine-sixteenths of an inch in diameter are assembled The contraangle attachment permits easy access through the wound and the application of the blade of the saw in the desired plane and direction of the section The blade of the saw is extremely fine, so that a very true, thin line of osteotomy can be secured Section should be definitely perpendicular to the surface of the ramus Any beveling of the edges encourages lateral displacement of the condylar fragment and upward displacement of the lower fragment The division of the last few millimeters of bone at the anterior and posterior borders of the mandible is completed with a fine osteotome because the circumference of the saw blade reaches beyond the limits of exposure in these positions Closure is effected in layers without drainage" The same procedure is carried out on the opposite ramus The mandible is then shifted into the desired position and immobilized by means of wires passed between hooks on orthodontic bands affixed to the upper and

lower teeth Complete immobilization is maintained for at least 4 weeks, and partial fixation for 2 weeks thereafter Up to 1937 Hensel had employed this procedure 14 times and in each case wound healing took place by primary intention, osseous union was complete, and there was no injury to the facial nerve, inferior alveolar nerve, or parotid gland.

Technic of Ostectomy

Ostectomy of the mandible may be performed intra-orally or extra-orally While the latter procedure diminishes the danger of infection nevertheless it has definite objections. Should infection occur the wide separation of the periosteum necessary for sectioning may interfere with healing of the bone and lead to necrosis with a resultant pseudo-arthrosis. Furthermore, a gigli saw must be employed for the purpose, and this instrument does not permit of as accurate sectioning as does a chisel or a straight saw Moreover, if the jaw is not already edentulous at a convenient location, 1 or 2 teeth will have to be extracted, in order that there may be room for the excision, and to allow time for complete healing, this must be done 5 or 6 weeks before the patient

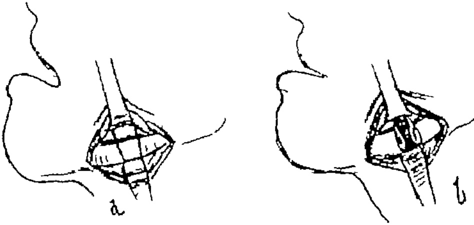


FIG 836. Submucous ostectomy for correction of prognathism. *a* soft tissues separated on labial and lingual surface of mandible, halfway to alveolar border Periosteum incised and freed from bone. Bone section to be removed outlined to pattern. *b* bone removed with gigli saw For details, see text.

enters the hospital whereas in the open operation the teeth may be removed at the time of the resection

The *submucous operation* is carried out as follows (fig 836) The soft tissues lying just below the margin of the mandible are drawn upward, and an incision 3 to 5 cm. long is made through skin fascia, and platysma down to the periosteum Through this opening the soft tissues are stripped from the jaw on its labial and lingual surfaces halfway up to the alveolar border At this level the periosteum is divided, and the bone is freed subperiosteally The danger of penetration into the buccal cavity will be minimized by having the assistant place a finger inside the patient's mouth to guide the elevator The soft tissues are then retracted the pattern of the section to be removed is laid on the bone, and with a gigli saw the outlined segment is resected. The same procedure is carried out on the opposite side

In the *open operation*, after the bone has been freed a previously prepared pattern representing the amount to be resected is placed on the bone and outlined with a scalpel. The soft tissues are protected by means of a metal spatula, and while the bone is steadied by the assistant, several holes along the proposed lines of excision are made with a burr driven by a dental engine. The resection is completed by chiseling through the bone

between the holes Or a gigli saw may be passed through the topmost drill hole and the bone divided from above downward, the remaining bridge of bone above the hole being severed with a chisel driven by a mallet (fig 837) Some surgeons prefer to use a motor-driven saw for the sectioning If this instrument is employed, it must be kept moist with a continuous stream of normal salt solution as a precaution against burning the tissues

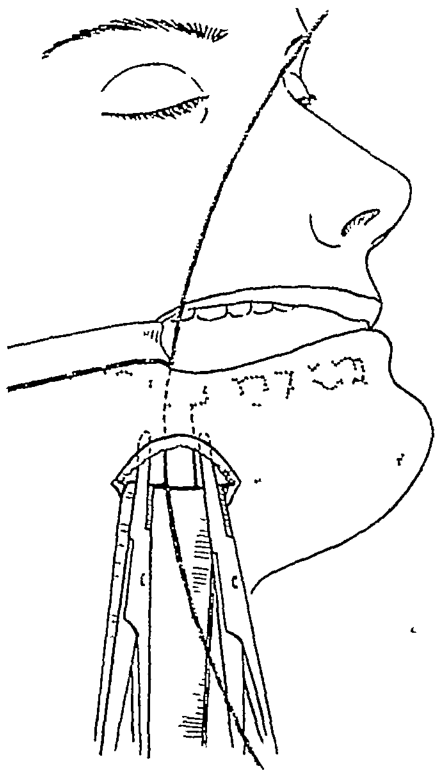


FIG 837 Ostectomy performed with gigli saw (Kazanjian)

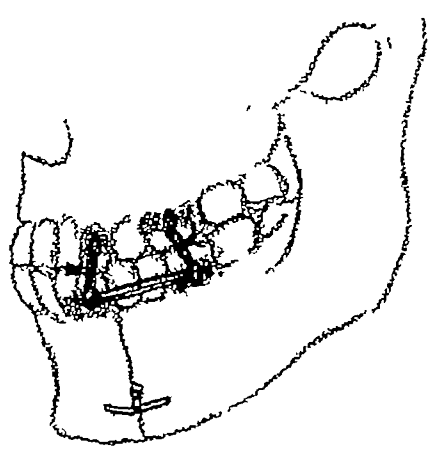


FIG 838 Immobilization following ostectomy by silver wire passed through drill holes in lower borders of cut bones Upper and lower jaws fixed by interdental wiring (Blair)

Following the ostectomy any remaining irregularities are smoothed down with a bone-forceps, the bone is repositioned, and the fragments are immobilized by means of the previously constructed splint (fig 832) Blair (14), in addition to using intra-oral fixation, secures the fragments with silver wire or chromatized catgut passed through drill holes made in the lower border of the bone and tightens the wires after the intra-oral fixation is complete (fig 838) But this seems unnecessary and carries the further

danger of introducing a foreign body into potentially infected and traumatized tissue. Finally, the wound is closed and drainage is instituted for a few days.

If the prognathism is merely simulated by a hypertrophy of the subcutaneous tissue, correction is an easy matter A horizontal incision 4 to 5 cm. long is made beneath and parallel to the lower margin of the mandible The skin is retracted, and the excess subcutaneous fat and areolar tissue are removed In cases where the deformity is due to a bony hypertrophy, the bone may be chiseled off through a similar incision, any remaining irregularities being smoothed down with a rasp The soft tissues are then replaced, and the skin margins are approximated with an intradermal suture

Micrognathia (Receding Lower Jaw)

Micrognathia, commonly referred to as "bird face," is a unilateral or bilateral shortening of the mandible. It is characterized clinically by a recession of the chin, malocclusion of the teeth, difficulty in phonation and mastication, and a tendency to oral sepsis and dental decay When the condition is unilateral the relative shortness of the ramus causes a deviation of the chin to the affected side, with buckling of the soft tissues and a resultant fulness of the cheek, the unaffected side appearing flattened and elongated The amount of shortening of the ramus can be determined by a comparison of lines drawn from the center of the chin to the tragus on either side. In cases of bilateral shortening the lower lip and chin will lie posterior to a vertical line drawn through the glabella and upper lip (fig 824)

The deformity may be hereditary, or it may be acquired from trauma inflicted during delivery premature extraction of deciduous teeth, or ankylosis of the temporomandibular articulation before the mandible has attained full growth. Not infrequently, micrognathia is simulated by an overdevelopment of the maxilla (maxillary prognathism), by an abnormal projection of the alveolar processes, or by a fracture and backward displacement of the body of the lower jaw

TREATMENT

In young patients whose bones are still pliable the malocclusion of the teeth can often be corrected by orthodontic measures. A supplementary operative procedure will be required, however to correct the recession of the chin and thus complete the cosmetic effect. After the sixteenth year ossification has progressed to such a degree that no further benefits can be expected from such treatment, and surgery is the only recourse

In cases where there is fairly adequate occlusion of the teeth the chin may be built out either with a properly modeled piece of cartilage or bone or a fat-and fascia graft introduced into a previously prepared bed through a small incision below the chin (fig 839) Hensel (53) employs a bone graft taken from the ilium. His technic is as follows Through an incision below the chin an arch-shaped osteotomy with its central convexity at the symphysis is made through one-quarter of the thickness of the bone The flap of bone thus outlined is elevated with a thin-bladed osteotome, and the transplant, fashioned to the desired size and shape, is wedged beneath it, no further fixation being employed (fig 840) The soft tissues are then undermined sufficiently to permit of closure without tension As an alternative to the above procedures, the

chin may be brought forward by means of a prosthetic appliance inserted into a previously prepared skin-lined pocket in front of the symphysis and attached to the lower teeth or to a dental plate (fig 841) The technic for the preparation of the skin-lined pocket is described on page 142

If the deformity is the result of an overdevelopment or forward projection of the alveolar processes, correction may be accomplished by extraction of the maloccluded teeth and excision of the abnormally developed alveolar processes, followed by the insertion of an artificial denture

In cases of marked shortening of the ramus with malocclusion of the teeth the mandible must be lengthened, and this is accomplished by sectioning either the ramus or the body of the bone and shifting forward the lower fragment on the upper

FIG 839 Correction of micrognathia unassociated with malocclusion by use of modeled cartilage graft introduced into prepared bed through small incision below chin

(fig 826) Sectioning of the ramus has the great advantage that the operation can be performed without penetration of the oral cavity But it is applicable only to minor degrees of recession, for at best it can advance the bone but 1 5 cm Further forward shifting would not leave sufficient contact between the fragments to permit of their union Moreover, sectioning of the ramus can be performed only on one of normal thickness, and in the majority of cases of micrognathia the bone is too atrophied to warrant such a procedure

While sectioning of the mandible through the body permits of any amount of lengthening, it is objectionable in that it necessarily involves penetration into the oral cavity and wiring of the fragments, with the associated danger of infection, suppuration, and sequestration In addition, the wide separation of the fragments required in many

cases frequently entails a prolonged convalescence, and may lead to non union and necessitate the use of a bone graft. To overcome the latter objection, various forms of oblique and "staircase" sectioning have been devised, to provide for wide separation of the fragments and at the same time permit of a broad surface contact.

Preoperative Management

Prior to operation any pre-existing ankyloses should be relieved (p 1253) and the mouth rendered as aseptic as possible Teeth are scaled and polished, cavities filled, and

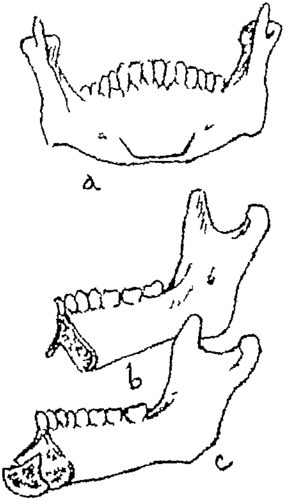


FIG. 840. Correction of micrognathia unassociated with malocclusion by use of bone graft. *a* bone flap outlined. *b* flap elevated with thin-bladed osteotome. *c* modeled iliac graft wedged in place. For details, see text. (Hensel)

carious teeth and infected roots extracted. Adequate dental splints are constructed for the purpose of immobilizing the fragments postoperatively In children operation is best delayed until the permanent bicuspids have erupted.

Osteotomy through Ramus

Blair (11) operates essentially as follows (fig 842) A vertical skin incision 2 cm. long is made in front of the auricle over the posterior border of the ramus. The skin is drawn forward to expose the parotid sheath, and the parotid gland is retracted backward

until the posterior border of the ramus comes into view A full-curved aneurysm needle with a curvature 4 cm in diameter is threaded with a silk carrier, passed behind the ramus, hugging the bone closely, so as to avoid penetration of the oral mucous membrane, and is made to emerge through the cheek in front of the ramus Should the oral cavity be inadvertently penetrated, it is advisable to terminate the operation and postpone it for several weeks With the silk carrier serving as a pilot, a gigli saw is carried around the bone. As a precaution against damage to the skin during the sawing, a small steel tube is passed over the anterior end of the saw The saw-cut is made downward and forward, about 5 mm lower in front than behind and at a level

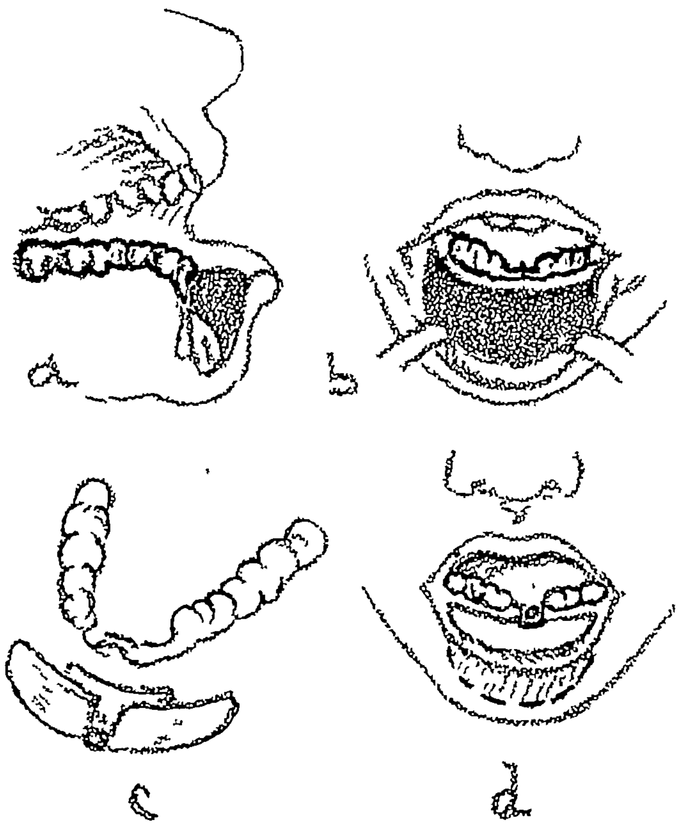


FIG 841 Correction of micrognathia unassociated with malocclusion by introduction of prosthesis into skin-lined cavity *a–b*, sectional and frontal views, showing soft tissues separated from mandible and teeth fitted with cap-splint, to hold graft-covered mold *c*, splint and tray *d*, graft-covered mold held in place by tray screwed to splint After epithelization, prosthesis introduced into skin-lined cavity, to carry chin forward (*McIndoe*)

5 mm above the occlusal surfaces of the inferior molars If the deformity is bilateral, the procedure is repeated on the opposite ramus After the bone has been sectioned, a block of rubber or wood is inserted between the upper and lower molars on either side and the chin elevated Thus the masseter and internal pterygoid muscles are stretched and the jaw brought forward As the bone is advanced, the saw-cuts separate in front and remain in contact at their posterior borders

Fixation of the re-posed mandible is obtained by intermaxillary wiring of the teeth, as prescribed for fractures of the mandible The forward positioning of the jaw is maintained by wiring the upper first or second maxillary premolar to the last available mandibular molar, and the elevation of the chin by wiring the lower canines or first premolars to the teeth directly above them

Osteotomy through Body of Mandible

Various types of vertical and oblique osteotomies have been suggested, as illustrated in Figure 826 (21, 29, 38) The best operation of this type is probably that of Kazanjian (64), whose technic is as follows An incision is made over the crest of the alveolar ridge, beginning in the retromolar region and passing forward to the second bicuspid tooth If the section cannot be made except through the dental root, the offending tooth is extracted. The buccal side of the lower jaw is then freely exposed, and with a

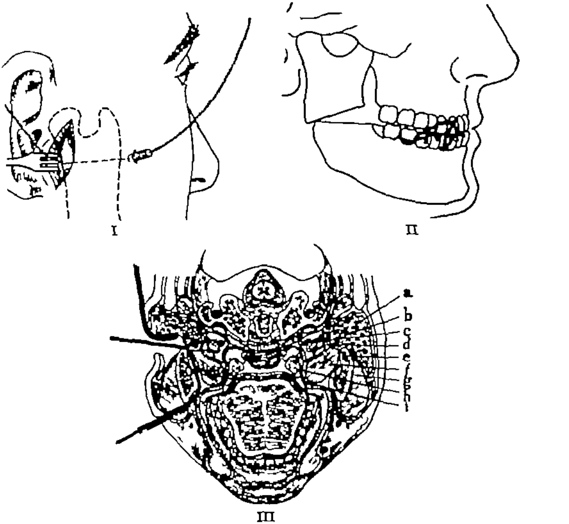


FIG. 842. Blair's subcutaneous osteotomy of ramus, for correction of micrognathia. *I* gigli saw in place. Skin protected by metal tube. Bone cut through at level 5 mm. above occlusal surfaces of inferior molars. (Diagram shows saw-cut too high.) *II* forward position maintained by wiring maxillary premolars to last mandibular molar and elevation by wiring mandibular canine or first premolar to teeth directly above. *III* sectional view showing relation of saw to *a* parotid gland *b* temporo-maxillary vein *c* internal carotid artery *d*, external carotid artery *e*, ramus of jaw *f* internal pterygoid *g*, masseter muscle *h*, tonsil *i* wall of pharynx.

surgical burr the mandible is cut through diagonally (fig 843) The same procedure is carried out on the opposite side The anterior fragment is then shifted forward, until the teeth fall into proper occlusion Holes are made in the extreme ends of the disconnected bone, and the fragments are anchored together in their new relationship by means of a #20 gauge brass wire. Drainage is instituted through a stab wound made externally below the mandible The intra-oral wound is closed, and the upper and

lower jaws are fastened together with elastic bands attached to dental splints previously prepared The jaw is held forward by means of a wire suture passed through the

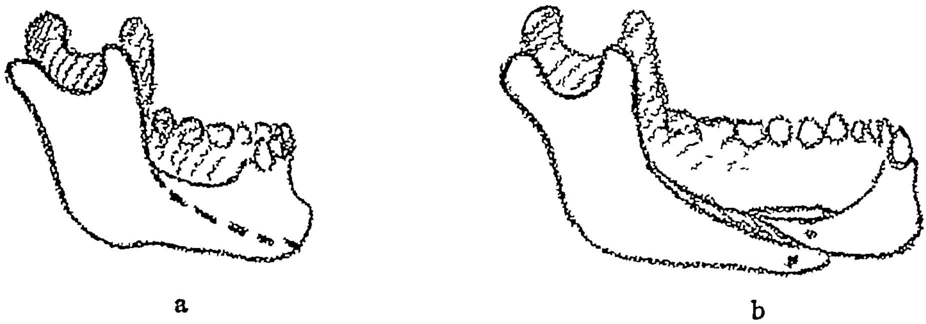


Fig 843 Kazanjian's oblique osteotomy, for lengthening body of mandible *a*, dotted line shows direction of sectioning *b*, anterior fragment shifted forward, until teeth fall into proper occlusion Holes drilled in fragments for passage of # 20 gauge brass wire, to immobilize bones in new relationship

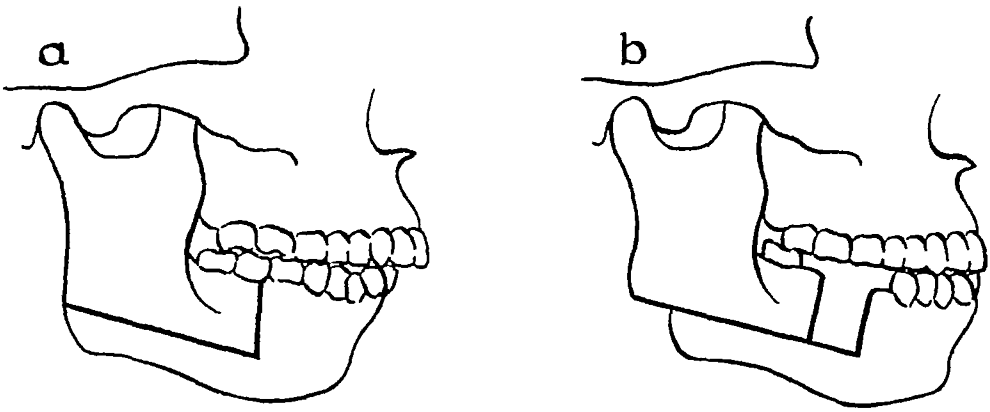


Fig 844 Kazanjian's L-shaped osteotomy, for lengthening body of mandible *a*, outline of osteotomy, beginning 5 mm above angle, passing forward to bicuspid region, and vertically upward to alveolar ridge *b*, anterior fragment slid forward into normal occlusion

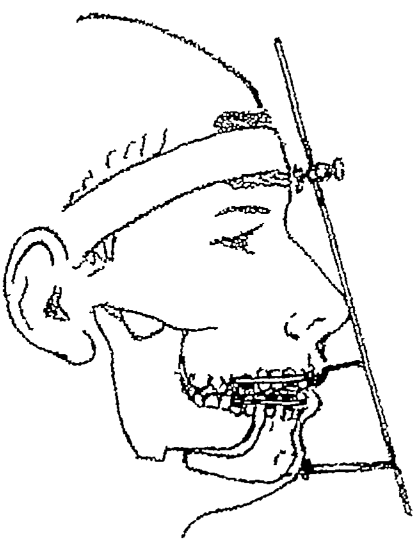


Fig 845 Method of immobilizing anterior fragment in forward position Brass wire passed through drill holes in symphysis, brought out through skin, and attached to median bar affixed to upper teeth and forehead frame (Kazanjian)

symphysis and attached with an elastic band to a metal bar affixed to a forehead frame and to the upper teeth (fig 845) In some cases Kazanjian finds it more convenient

to elongate the mandible through an L-shaped incision in the bone beginning 5 mm. above the angle, passing horizontally forward to the bicuspid region, and then vertically upward to the alveolar ridge (fig 844)

Limberg (78) operates in two stages, as follows (fig 846) Two or 3 months prior to the contemplated resection a piece of rib 3 to 4 cm in length is transplanted be

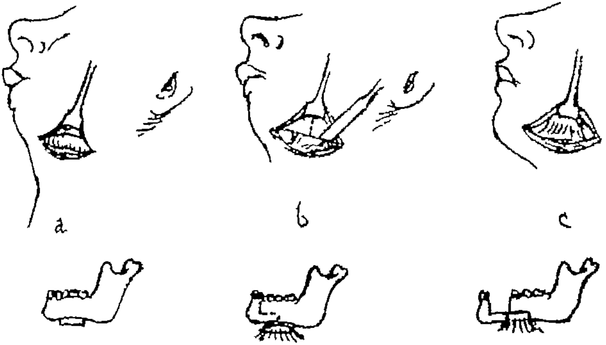


FIG. 846. Lengthening of mandible with bone graft. *a*, *First Stage*. Rib graft 3 to 4 cm. long transplanted beneath periosteum of mandible, at site of proposed osteotomy *b* *Second Stage*. Two or 3 months later, mandible exposed. Rib graft freed from mandible, but left attached to soft tissues by means of pedicle. *c* "staircase" osteotomy performed. Fragments separated. Ends of graft freshened, and graft wedged in between mandibular fragments. (Limberg)

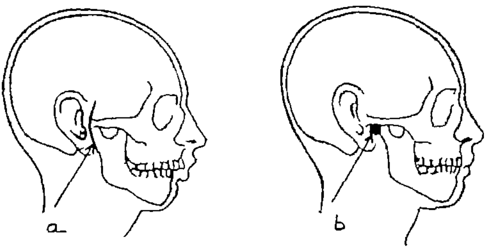


FIG. 847 Correction of micrognathia by advancement of condyle. *a* incision outlined. *b* condyle displaced forward. Quadrilateral section of rib cartilage inserted between advanced condyle and bony acoustic meatus. (Babcock)

neath the periosteum of the mandible at the site of the proposed osteotomy As soon as the nutrition of the transplant is established, the second stage of the procedure is carried out. Under local anesthesia the mandible is exposed through the previous external scar The rib graft is dissected away from the mandible with a chisel, being left attached to the soft tissues by means of a pedicle Through an intra-oral incision

a "steplike" osteotomy is performed through the body of the bone with a drill and osteotome, and the fragments are forcibly separated The ends of the graft are freshened, and the transplant is wedged in between the mandibular fragments and secured with a few catgut sutures Finally, the skin is closed and the oral wound packed with iodoform gauze which is left in place for 8 to 10 days

Babcock (7) corrects the condition by advancing the condyle of the mandible (fig 847) A vertical incision is made in front of the auricle and the wound retracted to expose the joint The head of the mandible is displaced forward by pressure with a periosteal elevator A quadrilateral section about 20 mm long taken from the sixth and seventh costal cartilages is inserted between the advanced condyle and the bony acoustic meatus The wound is closed with #35 B & S gauge annealed rustless steel wire After the fourth day the patient is permitted to masticate Babcock states that the operation is effective, simple, and produces but slight disability

Open Denture (Open Bite)

Open denture is a condition characterized by an inability to bring the teeth into normal occlusion It is usually associated with a protrusion of the chin and an obtuse mandibular angle which in extreme cases may approximate a straight line The deformity may be congenital, or acquired as a result of malunited fractures, inflammatory states, or disturbances in calcium metabolism

De Coster (28) classifies the various forms of open bite according to the co-relation of the arches

"(1) The bite is open but the general curve of the arch is maintained
 (a) Deviation of the two arches in their anterior part
 (b) Deviation of a single arch maxillary, mandibular
(2) The line of occlusion is broken, owing to an abnormal inclination that can be placed at any place on the line of occlusion of
 (a) The two arches
 (b) A single arch maxillary, mandibular
(3) The rupture of the line of occlusion is local maxillary-anterior, posterior, mandibular-anterior, posterior

The first case may be due to
 (a) A lesion of the temporomaxillary articulation
 (b) A muscular lesion which prevents closing the mouth
 (c) An insufficient length of the vertical part of the mandible
 (d) An increase of articular height at the molar level
 (e) An insufficient development of the skull and an exaggerated inclination of the anterior part of the cranial base
 (f) An insufficient development of the anterior part of the mandible

"In the second category we have cases in which the arch or the maxilla is affected, localized either in the maxilla or in the mandible, affording a view of purely mechanical deformation In the third class are to be found cases of limitless deviation "

Mild forms of open bite occurring before ossification has taken place may be corrected by orthodontic measures Angle, according to de Coster (28), advised the use of an arch appliance, as follows "The mandibular and maxillary arches are supplied with bands on the first molars The arch is lying under the level of the incisors and

above this level at the mandible. The incisor teeth are attached to the arch producing a flexion so as to bring the attached arch to the same level. The curved arch will produce a vertical reaction or tend to straighten its level. The molars must support this twofold reaction In order to ensure the safety of the molar teeth Angle advises a slow and not a too powerful action Rest periods are arranged between the periods of pull to relieve the alveolar bone and to prevent it following the extrusion of the incisors. When the arch is narrow Angle advises making the expansion without inter

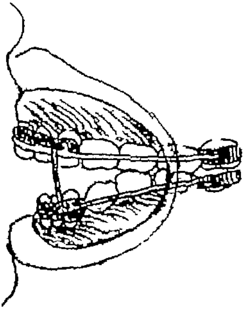
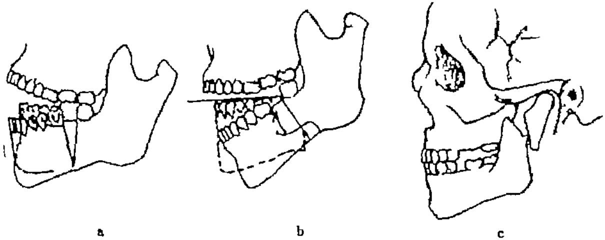


FIG. 848. Correction of mild forms of open bits in children by elastics stretched between incisor bands on maxillary and mandibular arches. (Case)



a b c

FIG. 849 Correction of open bite. *a* V-shaped excision in body of mandible. Dotted lines show result of repositioning anterior fragment. *b* S-shaped osteotomy Dotted lines show result of repositioning anterior fragment (Blair) *c* osteotomy through ramus (Kostečka)

fering with the open-bite. In severe cases he slightly grinds the masticating plane of the molars, but only at the end of the previous operation He states that open-bite cases are the most difficult we can meet with ' Case employs a maxillary and mandibular arch with incisor bands between which he places elastic bands (fig 848) After ossification has taken place, lengthening of the teeth by the use of porcelain crowns may be sufficient to bring them into occlusion.

In more severe cases occlusion can often be brought about by the performance of a straight, arched, or S-shaped submucous osteotomy of the mandible at a point in

front of the first occluding tooth on either side (fig 849-b) This is advisable, however, only when the oral cavity is of sufficient size to permit of occlusion without crowding of the tongue If the jaw is abnormally long, the best results will be obtained by the removal of a V-shaped section of bone, with its base directed upward, from each side at the sites of maximum curvature (fig 849-a) Following either of the above procedures, the anterior fragment thus mobilized is advanced upward until the teeth meet in normal occlusion The parts are held together by some form of interdental splint for 6 to 8 weeks, to overcome the pull of the suprahyoid group of muscles

When the open bite is due to a prognathic upper jaw, it has been suggested that the os incisivum be displaced posteriorly A canine tooth together with its alveolus or a strip of bone is resected from either side of the palate The os incisivum is then fractured backward and fixed in place by the use of a previously prepared splint

Minor Deformities of Jaws

Abnormal Prominence of Mandibular Angles

This condition is manifested by a "square jaw" appearance and is due either to a hypertrophy or exostosis of the angle of the mandible or to an abnormal thickness of

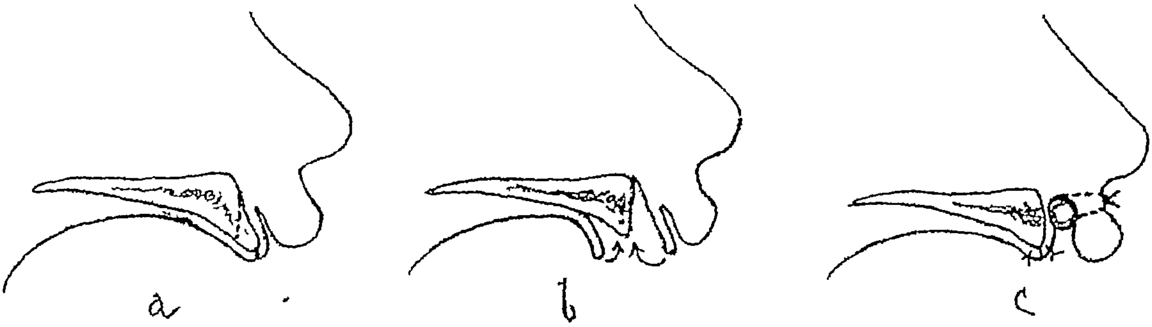


FIG 850 Reduction of prominent alveolar ridge *a*, incision made along prominent margin of bone. Dotted line indicates amount of bone to be excised *b*, soft tissues elevated on labial and palatal surface Excess bone removed with rongeur *c*, margins of incision approximated over reduced bone Gingivolabial sulcus maintained by flexible rubber tube inserted under lip and fixed in place by suture passing through full thickness of lip (Kazanjian)

the masseter muscle In the former case the excess bone may be chiseled or sawed off through incisions made below the angles When the deformity is due to an overdevelopment of the masseter, reduction may be obtained by means of a pyriform excision of the muscle tissue without serious interference with function

Abnormalities of Alveolar Ridge

In cases where the alveolar ridge is so prominent as to render the wearing of a denture impossible, Kazanjian (65) operates in the following manner (fig 850) "An incision is made along the prominent margin down to the bone All tissues are carefully elevated, not only to the palatal surface but also anteriorly, well up to the anterior nasal spine and canine fossa Extensive undermining of the tissues is important Excessive bone is removed by a rongeur, the labial flap is carried high up and the margins of the incision are approximated by interrupted sutures The removal of bone allows the labial flap to slide to a higher position, which is maintained by placing a small flexible rubber tube well up under the lip and passing interrupted mattress sutures around it and

through the lip on to the face. These are so placed as to create an upward tension on the mucous membrane surface They are tied over gauze to prevent the cutting of the skin. A dressing is then placed over the lip and strapped in place with adhesive. This adhesive strap is split and one half placed over the nose for support. To help control edema and to maintain pressure without, a double elastic band may be fastened under tension with adhesive over the lip dressing The band can be removed the next morning, but the sutures and the rubber tube should not be removed for four or five days. The tension of the rubber tubing maintains adequate and equalized pressure on all the tissues and ensures a good gingivolabial fold, which will not close when the sutures and the tubing are removed. In operations on the anterior part of the upper jaw, it is often necessary to remove a section of the anterior nasal spine in order to allow a higher buccal sulcus.'

SURGICAL AFFECTIONS OF TEMPOROMANDIBULAR JOINT

Temporomandibular Ankylosis

Chronic ankylosis of the temporomandibular articulation is a serious condition and demands surgical intervention If left untreated, it interferes with oral hygiene mastication, and phonation, and, in children, leads to retardation of bone growth and deformity Should intra-oral disease develop, the fixity of the jaws may prevent approach to the pathologic lesion and incur grave consequences.

The first to undertake correction of this condition was Esmarch, who in 1851 removed a wedge shaped section from the body of the mandible, but the operation proved unsuccessful. Humphry (55) excised the condyle for arthritis in 1856 The operation of arthroplasty was introduced by Verneuil (110) in 1860 Helferich (49) was the first to interpose muscular flaps between the osteotomatized fragments following sectioning of the condyle. Credit for placing the operation on a practical basis, however, belongs to Murphy and Blair, who standardized the technic so as to give uniformly satisfactory results. Murphy (88) stated "The operation is one of the most gratifying in bone and joint surgery as far as results are concerned and one of the easiest of execution."

The description of the condition and its treatment will be limited to chronic temporomandibular ankylosis of an osseous or fibrous nature Acute and transitory limitation of motion of the joint caused by hysteria, acute infectious disorders, such as tetanus, local reflex spasms consequent upon diseases of the mouth, parotid gland and auditory apparatus, and acute inflammatory diseases of the joint are problems for the internist and will not be discussed in these pages.

Anatomic Considerations

For a better understanding of the surgical problem it is advisable to review briefly at this time a few pertinent anatomic facts referable to the joint in question (fig 851)

The temporomandibular articulation is a freely movable, gliding hinge joint composed of the mandibular fossa and articular eminence of the temporal bone above and the condyle of the mandible below and is completely enclosed in a capsular ligament. The mandibular fossa is a large depression bounded anteriorly by the articular tubercle and posteriorly by the tympanic plate, which separates it from the external acoustic meatus. Anteriorly the cavity is covered with cartilage for articulation with the head

of the condyle, the posterior portion is non-articular and is formed by the tympanic plate The condyle of the mandible is oval, its long axis being transverse to the ramus, its articular surface is convex and covered with cartilage

Lying between the articular surfaces of the joint is the articular disk, or meniscus, an oval plate of fibrocartilage, concave above and below and thicker at the periphery than at its center, where it is frequently perforated A few fibers of the capsular ligament and some of the fibers of the external pterygoid are inserted into it, drawing it forward when the mouth is open This disk divides the joint into two distinct articulations, the larger one lying between the disk and the mandibular fossa and the smaller one between the disk and the condyle, both cavities being lined with synovial membrane When the mouth is opened, both joints come into play, the hinge action taking place in the lower and the gliding motion in the upper Conversely, when the mouth is closed, the hinge action is transferred to the upper and the gliding motion to the lower compartment When the jaw is protruded, the forward gliding action is in evidence

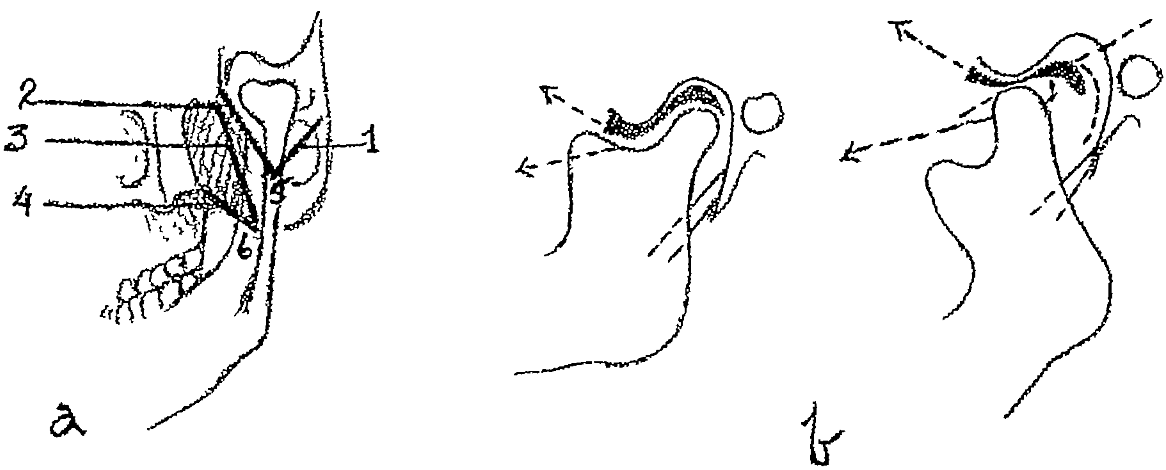


FIG 851 Temporomandibular joint *a1*, zygomaticomaxillary ligament, *2*, stylomaxillary ligament, *3*, sphenomaxillary ligament, *4*, pterygomaxillary ligament, *5*, attachment of first 2 ligaments, *6*, attachment of last 2 ligaments *b*, relation of condyle to meniscus and glenoid fossa with mouth closed and open Arrows show direction of muscular pull Straight dotted line, direction taken by condyle in opening jaw

in the upper section In mastication the condyles glide alternately, one remaining in place and the other rotating on its disk

The *capsular ligament* is thin and loose and is attached outside of the articular surfaces of the bone The strongest part is the *temporomandibular* (*external lateral*) *ligament*, arising from the zygoma and running downward and backward to its insertion in the outer side of the neck of the condyle (42) Next in thickness is the *sphenomandibular* (*long internal lateral*) *ligament*, extending from the spine of the sphenoid to the lingula of the mandible It has no direct connection with the joint Between this ligament and the ramus pass the internal maxillary artery and vein, the inferior alveolar nerve, the auriculotemporal nerve and middle meningeal artery, and a portion of the external pterygoid muscle The *stylomandibular ligament*, a thickened portion of the deep cervical fascia, passes from the styloid process to the angle of the mandible Because it is the weakest part of the capsule, in case of suppuration the pus usually finds exit at this point

The motion permitted by the mandibular articulation is more varied than that of any other joint, and comprises extension, retraction, depression, and elevation, as well as

intermediate movements between those mentioned The muscles concerned in this activity are described on page 1202

Etiology

Chronic temporomandibular ankylosis may be either congenital or acquired The congenital type is generally ascribed to an abnormal development of the joint itself or of its surrounding structures, or to injury or infection during delivery (24) The acquired form appears most commonly in early life (51) and affects both sexes equally (82) It is initiated by the same causes that give rise to ankylosis in other joints, namely trauma and infection

The etiologic factors responsible for the *intra-articular* variety are (1) traumatisms, such as are produced by a blow delivered on the side of the jaw or on the chin, forcing the condyle against the glenoid fossa with or without fracture or dislocation of the condyle, (2) inflammatory or infective processes which (a) originate within the joint itself as an osteo-arthritis, (b) extend into it from diseases of the surrounding structures, such as otitis media, parotiditis, dento-alveolar abscess, or mandibular osteomyelitis, or (c) spread through the blood stream as secondary metastatic processes in the course of acute infectious diseases—for instance, gonorrhea and scarlet fever

Common causes of the *extra-articular* type are (1) bony growths and depressed fractures of the malar zygomatic compound which infringe upon the movement of the joint and (2) cicatricial contraction consequent upon a loss of skin, mucous membrane, or muscle between the temporomandibular joint and the body of the mandible following operative or accidental wounds, or as a result of burns, radiotherapy and inflammatory and infective processes, such as cancrum oris and lupus.

Pathology

From a pathologic standpoint mandibular ankyloses may be divided into three varieties (1) Intra articular (true) (2) extra-articular (false), and (3) combined intra and extra-articular Any of these types may be fibrous or bony in character (51) The *intra-articular* variety is marked by progressive joint destruction associated with fibrous tissue fixation destruction of the meniscus, thickening of the condyle, flattening of the mandibular fossa, and shrinking of the joint capsule, with a resultant partial or complete obliteration of the joint cavity Not infrequently, the scar tissue undergoes calcification, in which case x ray examination will show the condyle and the mandibular fossa fused into one continuous mass with no visible line of junction. In the *extra articular* type the joint becomes enveloped in cicatricial tissue or bone, and frequently all of its normal landmarks are effaced In rare instances osteomata and exostoses develop around the articulation

Diagnosis

Ordinarily the diagnosis of temporomandibular ankylosis offers no difficulty The patient usually presents himself several years after the condition has become established giving a history of inflammation trauma, or infection in and about the joint, followed by a gradual progressive inability to open the mouth, with an associated interference with mastication phonation, and oral hygiene. Frequently, the history

can be corroborated by the presence of scars and fistulae in the neighborhood of the articulation

The extent and character of the deformity will depend upon the age at which it appeared and upon whether one or both joints are affected If acquired after complete development of the bone, the condition will cause only slight disfigurement, but when it comes on early in life before the jaws are fully formed, the deformity is marked, owing to the interference with bone growth In bilateral ankylosis the lower third of the face is underdeveloped, the backward displacement of the chin simulating micrognathia Due to atrophy of the muscles of mastication and the unopposed action of the depressor muscles, the angles of the jaw are lengthened, and the body of the bone becomes convex in a downward direction The teeth are likely to be carious, owing to the difficulty of attending to oral hygiene, and because of the restricted space for normal eruption, they are forced into oblique occlusion with those of the upper jaw The deformity is further accentuated by an abnormal protrusion of the upper anterior teeth from pressure of the tongue In the unilateral variety there is a rounding of the cheek and a backward and lateral displacement of the chin on the affected side, owing to a lessening of the distance between the lower edge of the zygomatic arch and the angle of the mandible An attempt to open the mouth causes the chin to deviate toward the ankylosed side

The degree of restriction of movement will obviously depend upon whether the ankylosis is unilateral or bilateral, extra-articular or intra-articular, fibrous or osseous In bilateral intra-articular ankylosis there is complete immobilization of the joint, although slight motion on the part of the dental arch is possible, owing to the elastic property of the bone In the bilateral extra-articular type, when the patient attempts to thrust the jaw forward, the joint can be felt to glide under the palpating finger without deviation of the chin Unilateral fixation is manifested by movement of one side and immobility of the other, causing a deviation of the chin to the affected side on attempted motion (64)

X-ray examination of the joint in anteroposterior and lateral planes will show in the osseous type an excess of bone with a diminished articular cavity or a complete loss of outline If the ankylosis is unilateral, shortening of the ramus on the affected side is distinctly visible Tomography of the joint will often give information not afforded by ordinary roentgenography By this procedure the joint is shown on a homogeneous background, the shadows ordinarily produced outside of the joint being deleted by the movement of the tube column

Frequently, despite the most careful preliminary examination, it may still be impossible to determine whether the ankylosis is bony or fibrous, but this is of no moment, since in either case the surgical approach to the lesion is the same, and after the joint has been exposed, the diagnosis can be made at a glance

Treatment

Attempts have been made to relieve the condition non-surgically by forcible dilatation with levers and interdental appliances (fig 852), but not only are these measures ineffectual, causing the patient unnecessary suffering, but they are likely to aggravate the ankylosis by the trauma they occasion Permanent relief can be obtained only through operative intervention

Irrespective of the type of ankylosis, the operation should be performed as early as possible especially *in the case of children, since here a delay may* mean interference with dentition, underdevelopment of the jaw, and wasting of muscles. While in these instances it is true that the surgery itself may by traumatizing the condylar epiphysis interfere with the growth of the mandible nevertheless the deformity will be less pronounced than if the condition were left untreated If however, there are foci of infection present, they must be eliminated and 6 months allowed to elapse before operative intervention is instituted

The head is shaved well over the temporal region and draped the face being left in full view, in order that the muscular twitchings indicating infringement on the facial nerve may be observed (25) The operation may be performed under general or local anesthesia The former offers a problem since vomiting with the mouth closed may lead to asphyxiation but if a general agent cannot be avoided, it is best administered endotracheally, with the tube introduced through the nose. Local anesthesia is obtained by blocking the gasserian ganglion.

The choice of operative procedure will of necessity depend upon the cause of the ankylosis. In the *extra-articular* type, where the limitation of movement is due to cicatricial contraction of structures in the vicinity of the joint, removal of the binding

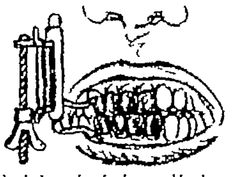


FIG. 852. Kazanjian s mechanical exerciser for jaw working by constant pull of elastic bands.

tissues and their replacement with grafts or flaps may be sufficient to restore function. In such cases the scar tissue is excised either extra or intra-orally, depending upon its location. During the dissection care should be taken to avoid injury to the parotid duct. Following resection of the cicatricial tissue the jaws are separated and the denuded area covered with a graft or a flap If the loss is limited to mucous membrane, the raw surface is covered with a thick razor graft on a stent mold held in place either with silkworm-gut sutures passed through the cheek or by means of a dental appliance (p 1042)

The lost membrane may also be replaced with a neck flap turned into the mouth, skin side in, as illustrated in Figure 853 The technic is as follows Two weeks prior to the removal *of the scar tissue a flap from the lateral aspect of the neck*, with its pedicle lying on the margin of the mandible, is raised and replaced in its bed to enhance its nutrition At a second sitting an incision is made along the lower border of the mandible, penetrating the buccal cavity and through this opening the intra-oral scar tissue is excised The flap is raised and drawn through the submandibular incision into the mouth so that its epithelial surface will face the oral cavity The free end of the flap is sutured to the upper border of the buccal wound and the two sides to its lateral borders Three or 4 weeks later the pedicle is severed at its site of reflection,

and the cut end is sutured to the lower edge of the mandible to create a new gingivobuccal sulcus The stump of the pedicle is then returned to the neck (64)

If the excision of cicatricial tissue involves muscle and skin as well as mucous membrane, replacement is accomplished by one of the methods detailed on page 1046

In the *intra-articular* variety of temporomandibular ankylosis surgical reconstruction of the joint itself would seem to be the ideal method of correction Practically, however, the formation of a pseudo-arthrosis has proven more satisfactory, inasmuch as it restores efficient motion and stability to the joint without incurring the danger of perforation of the thin wall of the glenoid fossa into the cranial cavity, or rupture of the internal maxillary artery—accidents likely to be associated with the former procedure

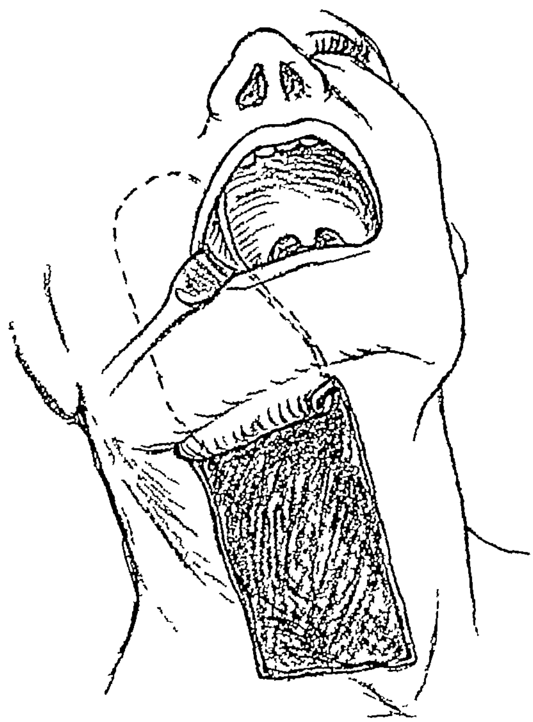


FIG 853 Correction of cicatricial ankylosis by neck flap Scar tissue removed Neck flap raised passed through incision below mandible, and sutured in place over raw area, skin side of flaps facing oral cavity After vascularization, pedicle cut along line of reflection Flap sutured into lower margin of defect, and stump returned to neck

Incision of Approach Many incisions for exposure of the joint are in current use, all of them designed to protect the facial nerve and internal maxillary artery and to leave a minimal scar The most popular avenues of approach are through (fig 854). (1) A vertical incision in front of the ear, beginning on a level with the upper pole of the auricle and ending just above the level of the exit of the main trunk of the facial nerve (64) (2) An S-shaped incision beginning just behind the lobule of the ear, passing upward 1 cm in front of the auricle to the level of the zygomatic arch, and curving over it for a distance of 2 cm (92) (3) An L-shaped incision, the vertical arm starting at the upper border of the zygoma and extending upward for 4 cm in front of the ear on a line with the posterior margin of the ramus of the mandible, and the horizontal limb beginning at the lower end of the vertical incision and extending along the upper border of the zygoma for 2 cm (50) (4) An L-shaped incision, the vertical limb 4 cm in length, extending from the hair line to the upper margin of

the zygoma in front of the ear, the horizontal limb curving forward on the superior margin of the zygoma for a distance of 1.8 cm , and then upward to avoid injury to the orbital branch of the facial nerve (87, 88) (5) A conchal incision with a separation of t he cartilaginous acoustic canal (4) (6) An incision beginning in front of the lobule, passing upward in front of the ear to a point 1 cm above its free upper border, and from here curving forward and then downward to end at a point 2.5 cm. in front of the upper attachment of the ear (14) (7) An incision 2.5 to 3.5 cm long beneath and parallel to the lower border of the mandible beginning at the angle and extending forward The soft tissues including the insertion of the masseter muscle are stripped away from the outer surface of the ascending ramus as high as the sigmoid notch (96)

As a precaution against injury to the facial nerve the primary incision is made through the skin only The superficial temporal vessels are then identified and either ligated or retracted posteriorly The temporal fascia is incised vertically, to avoid

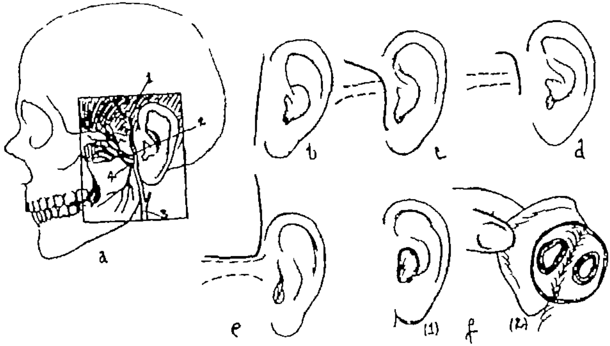


Fig. 854 Avenues of approach to temporomandibular joint a structures to be avoided: 1 superficial temporal artery 2, internal maxillary 3 external carotid 4 facial nerve. b-f various incisions of approach to joint. For details see text.

damage to the temporal branch of the facial nerve. The fibers of the masseter muscle over the zygoma are then severed and separated from the bone with a periosteal elevator The soft tissues including the upper pole of the parotid gland are retracted, and a vertical incision is made through the capsule of the joint to expose the neck of the condyle. The periosteum is stripped from around the bone over an area of 1.5 cm so that the bone may be sectioned subperiosteally without danger of injury to the internal maxillary artery Occasionally it will be necessary to resect 1 to 2 cm of the posterior extremity of the zygomatic process in order to obtain access to the bone. Hemorrhage is controlled by tampon pressure.

Resection of Bone The amount and location of the section of bone to be removed will depend upon the conditions encountered in and around the joint In any event, just enough should be excised to permit of a full range of motion Excessive resection must be avoided, as it will cause the muscles of mastication to pull the ramus too far

upward and will destroy the stability of the joint As a rule, a segment 1 to 1 5 cm long is sufficient The usual site of excision is at a point about 0 25 cm below the base of the condyle However, if the coronoid process and the incisura are fixed in the ankylosed mass, the sectioning is done through the ramus below the incisura

The ostectomy may be performed with a chisel, a dental burr on an electric engine, a gigli saw, or a nibbling forceps The latter instrument is preferable to a gigli saw, inasmuch as the saw is likely to break, owing to the acute angulation at which it is made to operate The bone is cut bit by bit in a series of small bites, beginning at the side and going progressively deeper During the cutting of the bone injury to the internal maxillary artery and the mandibular branch of the trifacial nerve which lie just behind the ramus can be avoided by means of a periosteotome passed between these structures and the neck of the mandible (fig 855) But with ordinary care, if the instrument is kept close to the bone and the operation carried out under direct vision, such a precaution is unnecessary As soon as the bone has been completely divided, the patient's mouth is opened This should be done gradually to prevent injury to the vessels and nerves which have become shortened during the period of ankylosis If after the resection the jaws cannot be separated, this is evidence of ankylosis of the opposite joint and calls for a similar resection on the other side

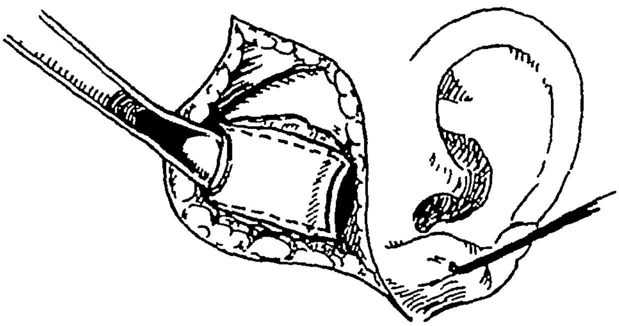


FIG 855 Resection of neck of condyle, for relief of ankylosis Internal maxillary artery and mandibular branch of trifacial protected by periosteotome passed beneath bone (Payr)

Prevention of Reunion. There is a difference of opinion as to the advisability of interposing material between the ends of the bone to prevent their reunion Foreign bodies, such as celluloid, Horsley's wax, gutta-percha (20), and silver plates, have been utilized for this purpose, but the practice has been abandoned, as in time it causes irritation and infection, with ultimate extrusion of the material Grafts of fascia lata and fat have been employed for the same purpose The use of flaps of temporal muscle and fascia has likewise been advocated These flaps, cut in the form of the letter U and pedicled on the upper margin of the zygoma, are wedged between the bone ends and tacked down with a few catgut sutures (14, 49, 87) But by the time such a flap has been dissected up, the pedicle is so small and the blood supply so impaired that the process amounts to the implantation of a free graft Generally speaking, the interposition of tissue is unnecessary, provided sufficient bone has been removed, inasmuch as reunion between the fragments will be prevented by the motion that necessarily follows

After the resection the soft parts are approximated in layers A block of wood is then introduced between the jaws and wired to the teeth, and a pressure dressing is applied Kazanjian (64) does not believe a mouth gag or other apparatus to be

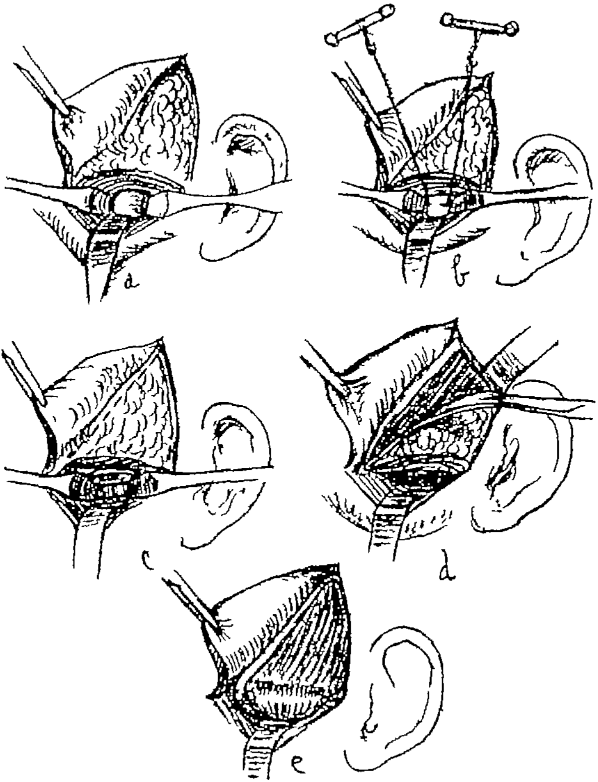


FIG. 856. Murphy operation for relief of temporomandibular ankylosis. *a*, joint exposed through L-shaped incision. Two curved periosteotomes passed behind neck of mandible, to protect internal maxillary artery *b*, bone divided with gigli saw *c*, segment of bone 1 cm. in length removed. Dotted line shows outline of flap in temporal fascia. *d–e*, temporal fascia flap raised, interposed between ends of bone, and fixed in position by sutures. For details see text.

necessary He states 'It has not been my custom to use mouth gags or dilators after operation, or to rush the joint into immediate use.'

The steps of Murphy s (87) operation for the relief of temporomandibular ankylosis

are essentially as follows Through an L-shaped incision in front of the auricle (fig 856-a) the skin and fascia overlying the bone are separated and reflected upward To protect the internal maxillary artery, the neck of the mandible is encircled by two curved periosteotomes passed behind it (fig 856-b) A small full-curved aneurysm needle armed with a silk thread to serve as a pilot for a gigli saw is then carried around the neck, and the saw is drawn through A segment of bone about 1 cm in length is removed Following the resection a flap of temporal fascia and fat pedicled below is interposed between the fragments and fastened in place by a few catgut sutures Finally, the wound is closed

After-Treatment Following operation the jaw is kept at rest for a week, the patient being placed on a liquid diet The sutures are removed in 4 or 5 days As soon as pain and tenderness have disappeared, physiotherapy in the form of light, heat, and massage is instituted, and the patient is encouraged to take regular exercises at stated intervals over a period of months An apparatus described by Blair and Ivy (14) will be found useful for the prevention of secondary contraction It consists of two "flat metal trays passing between the occlusal surfaces of the upper and lower teeth (fig 813) To the outer sides of each tray are soldered heavy wires which pass out of the mouth and curve backward over the cheeks in the manner of Kingsley splints The wire attached to the upper tray on each side turns down at a right angle about opposite the premolar region and ends in a hook about three inches lower down The wire attached to the lower tray passes directly backward horizontally and is provided with a hook at a point opposite the downward turn of the upper wire The dilating force is a heavy elastic band placed between these hooks on each side The dilating force can be regulated by the size and tension of the elastic bands In some cases, where it is advisable to aid in the forward movement of the condyle as the mouth opens, this can be accomplished by running a second rubber band between the hook on the wire attached to the upper tray and one placed at the extreme posterior end of the lower wire The apparatus can be removed at meal times or whenever desired, and replaced by the patient or some one in the house with him "

A paralysis of the facial muscles supervening 2 or 3 days after operation is not an uncommon sequela and is due to the stretching of the tissues It is no cause for alarm, however, as it disappears spontaneously within 2 or 3 weeks Residual deformities, such as micrognathia, p 1243, are corrected at a later date, and for the dental malocclusion the patient is referred to an orthodontist

Dislocation of Mandible

Dislocation of the mandible may be upward, backward, or forward, depending upon the direction of the traumatizing agent Upward dislocation is produced by a blow upon the chin while the mouth is open, especially in the absence of teeth, and is usually fatal, since one or both condyles are driven through the roof of the mandibular fossa into the skull Treatment consists in opening of the cranium above the mandibular fossa, repositioning of the condyle, and immobilization of the latter by some form of interdental fixation Backward dislocation is the result of a blow delivered on the front of the chin while the mouth is closed The condyle is driven against the tympanic plate, crushing the walls of the external acoustic canal In this type treatment is directed toward bringing the mandible forward and retaining it in its proper location

by interdental fixation. Forward dislocation may be due to a blow on the chin while the mouth is open or to muscular overstrain such as may be caused by taking too large a bite, laughing, or yawning In these instances the condyle slips over the eminentia articularis into the zygomatic fossa, the interarticular fibrocartilage is drawn forward by the external pterygoid, and the pull of the muscles of mastication locks the joint in a fixed position of open bite The spasmodic contraction is associated with considerable pain, and mastication and phonation are naturally interfered with Palpation reveals a hollow in front of the tragus and an abnormal location of the condyle Intra orally the coronoid process can be felt beneath the zygomatic arch If the dislocation is unilateral the chin rotates to the opposite side Treatment should be instituted at the earliest possible moment Because of the spastic contraction, reduction may be difficult and a general anesthetic be required. The surgeon, standing in front of the patient, places his thumbs, well protected, over the molar teeth on both sides and his fingers beneath the chin He then exerts downward pressure with the thumbs, in order to depress the condyle below the level of the eminentia articularis, and at the same time produces upward pressure on the chin with the fingers to rotate the condyle into the socket. As soon as the articular eminence is cleared, the condyle will slip into the mandibular fossa owing to the contraction of the muscles of mastication. The jaw is then immobilized for a few days by means of a circular head-chin bandage, so that the stretched and lacerated ligaments may be allowed to heal.

Chronic Recurrent Mandibular Dislocation

Recurrent dislocation of the mandible is characterized by a unilateral or bilateral fixation of the mandible whenever the jaws are opened beyond a given limit. The cause is unknown and has been ascribed to many factors such as deficient development of the articular tubercle, lack of depth of the articular cavity, malformation of the condylar head, and relaxation of the ligaments. Investigation at the time of operation however, has failed to show a relationship between these abnormalities and habitual dislocation (109) The condition has also been attributed to a displacement of the meniscus following an excessive contraction of the internal pterygoid muscle which is attached to its anteromedial aspect. It is thought that when the muscle contracts the thick portion of the meniscus comes to lie obliquely instead of transversely across the articulation thus causing it to remain locked

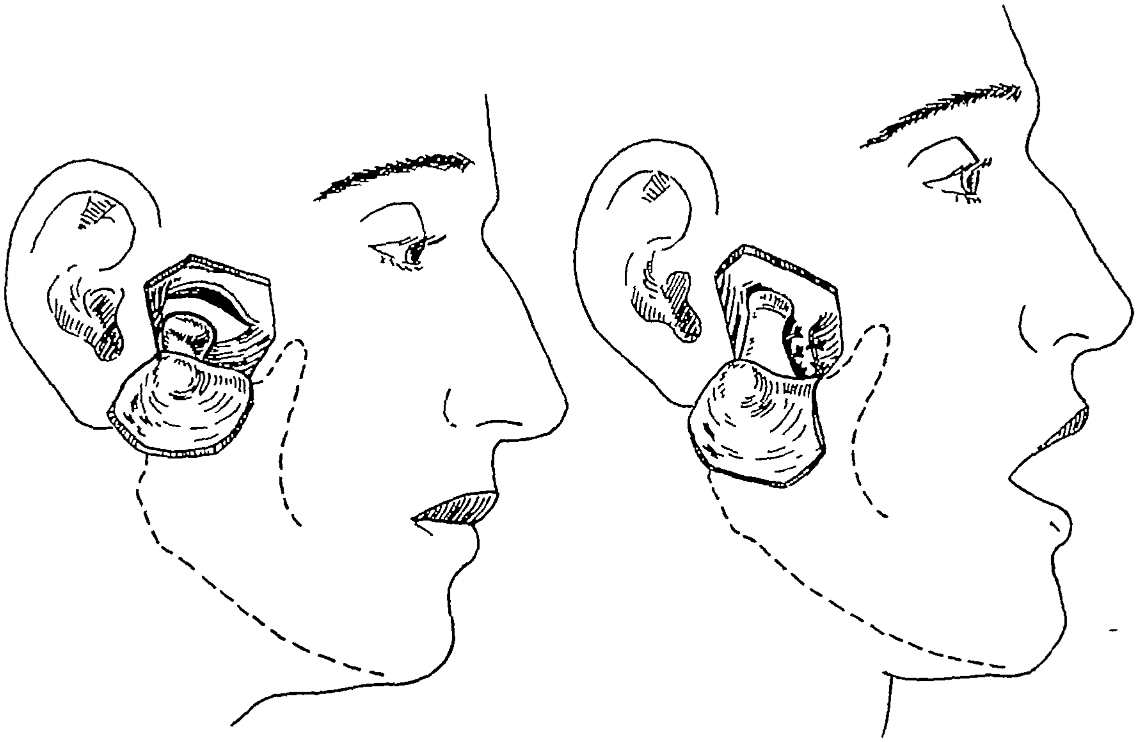
The symptoms vary from a slight sensation of snapping in the region of the joint to a recurrent habitual painful dislocation

Treatment

Since no definite pathologic lesion can be demonstrated, there is considerable controversy regarding the proper management of these cases, as evidenced by the numerous methods suggested for their relief Attempts have been made to reduce the size of the capsular ligament by surgical plication and by the injection of alcohol or iodin into the joint with the aim of causing its contraction. Schultz (105) reports successful results following the introduction of a solution of sodium psylliate The technic is as follows "The ball of the index finger is placed in front of the tragus, and the patient opens the mouth wide enough to cause the head of the condyle to subluxate, 'click,

or produce abnormal movement of the fibrocartilaginous disk The needle is inserted into the joint cavity and from 0 25 to 0 5 cc of the solution is deposited inside the joint cavity The injections are repeated weekly or biweekly on both joints until a sufficient fibrosis is obtained This occurs usually in from three to five weeks "

It has been suggested that a flap of temporal fascia be attached to the condyle and capsular ligament under sufficient tension to prevent forward dislocation (89), but it is questionable whether such a flap can be made of sufficient length or strength to furnish the desired result Symptomatic relief of the condition by means of intra-oral dentures to prevent excessive opening of the mouth have been advocated These contrivances, however, cause great annoyance and are in time discarded Other procedures have



a b

FIG 857 Correction of habitual dislocation of mandible by repositioning meniscus in front of temporomandibular joint, to limit forward movement of mandible *a*, temporomandibular joint exposed *b*, meniscus separated from posterior attachment, swung in front of condyle, and fixed to external pterygoid and masseter muscle (Konjetzny)

been directed toward deepening of the articular cavity by the removal of the meniscus, but this also has fallen short of satisfaction

Konjetzny (71) limits forward movement of the jaw by repositioning the meniscus in front of the temporomandibular joint, as follows (fig 857) The mandibular joint is exposed by turning down a U-shaped flap of temporal fascia The meniscus is separated from its posterior and lateral attachments but left united to the anteromedial portion of the joint capsule by means of a pedicle The external pterygoid muscle is severed from its insertion into the neck of the condyle, and the meniscus is rotated at right angles and secured with catgut sutures to the masseter and the external pterygoid muscles in front of the condyle The external flap is then replaced and sutured, and the mandible is splinted for 10 to 14 days

Mayer (85) operates in a more ambitious manner He corrects the condition by

introducing a bone block in front of the articular eminence in order to prevent forward displacement of the condyle—a procedure patterned after the bone-block operation for drop-foot. The operation is carried out under local anesthesia, so that the patient may open and close the mouth during the procedure. A horizontal incision 5 cm. in length is made along the zygoma, extending almost to the external acoustic meatus, and thence upward and backward over the base of the pinna (fig 858) The auricle is turned down exposing the base of the zygomatic process and the temporomandibular joint. The incision necessitates division of the superficial temporal vessels which run in front of the ear and also requires a strong retraction of the superficial temporal nerve One inch of the zygoma is resected by means of a motor-driven saw or a bone-cutting

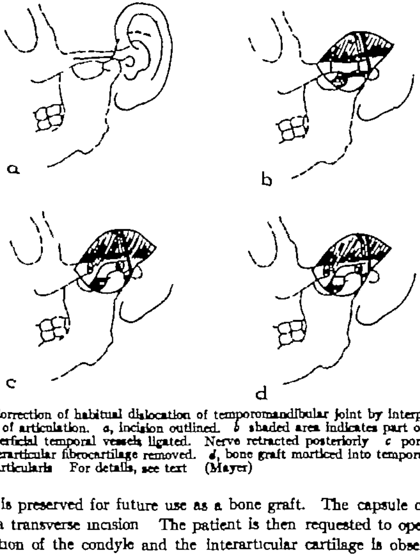


FIG 858. Correction of habitual dislocation of temporomandibular joint by interposition of bone block in front of articulation. *a*, incision outlined. *b* shaded area indicates part of zygoma to be resected. Superficial temporal vessels ligated. Nerve retracted posteriorly *c* portion of zygoma resected. Interarticular fibrocartilage removed. *d*, bone graft morticed into temporal bone anterior to eminentia articularis For details, see text (Mayer)

forceps and is preserved for future use as a bone graft. The capsule of the joint is divided by a transverse incision The patient is then requested to open his mouth, and the motion of the condyle and the interarticular cartilage is observed. If the cartilage is loose it is resected otherwise, it is left undisturbed. A groove for the reception of the bone graft is then hollowed out in the temporal bone just anterior to the eminence. Ordinarily the depth of the groove is about 3 mm. and the length 3.5 cm. its edges are made oblique, so that the graft will be firmly morticed when driven into position and will require no further fixation. The section of zygoma previously removed is now fitted into the groove The patient is again requested to open his mouth and if the operation has been properly performed, it will be found that forward dislocation of the mandible will be checked by the graft The procedure is terminated

by the approximation of the opposing margins of the capsular ligament, fascia, and skin A plaster cast is then applied and allowed to remain in place for 4 to 6 weeks While this operation is usually effective, it offers technical difficulties and entails the sacrifice of a portion of the zygoma as well as part of the origin of the masseter muscle

Groves (47) obtains good results from a much simpler procedure After exposure of the condyle by blunt dissection a hole is bored through the mastoid process with a $\frac{3}{16}$ inch drill A section of tendon 7 5 cm in length, procured from the palmaris longus or brachioradialis muscle, is passed through this aperture and carried around the neck

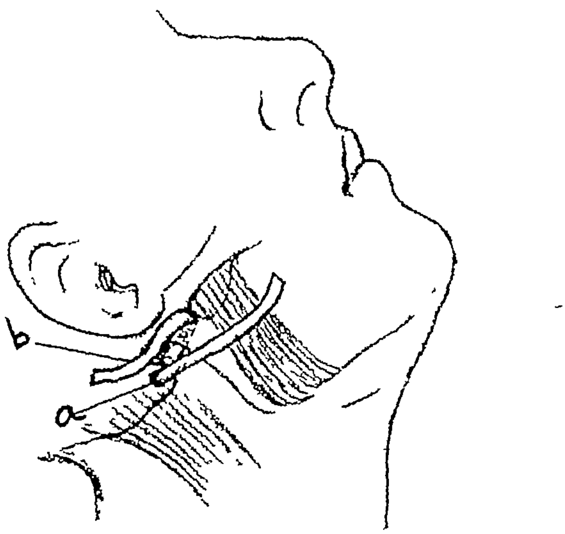


FIG 859 Correction of habitual dislocation of mandible by tendon passed through drill hole in mastoid process and carried around neck of condyle Two ends of tendon drawn tight, and overlapping portions sewn together *a*, drill hole in mastoid process *b*, tendon strip (Groves)

of the condyle The two ends of the tendon strip encircling the bone are drawn tight and the overlapping portions are sewn together (fig 859)

SNAPPING JAW (CRACKING JAW)

Snapping jaw, a condition manifested by a snapping sound when the mouth is opened, is the commonest chronic affection of the temporomandibular articulation, occurring most frequently in young female adults As a rule, the condition is unilateral The snapping sound has been attributed to the action of the condyle slipping off the meniscus and striking the articular eminence during the forward movement of the mandible In mild cases the snap may be audible only to the patient, but in the more severe forms it can be heard by others and is usually associated with considerable pain, particularly during phonation and mastication If the condition is progressive, in time a slight swelling develops over the joint, the movements of the jaw become limited, and the pain over the articulation increases and becomes more or less continuous Ultimately, it may terminate in ankylosis

The cause has been variously attributed to a congenital deficiency of the interarticular cartilage, malformation of the condyle, weakness of the capsule, arthritis following trauma, and excessive strain on the joint due to malocclusion of the teeth Frequently, patients give a history of overstretching of the articulation, such as may result from prolonged dental manipulation Von Stapelmohr (109) draws a distinction between

idiopathic jaw cracking, jaw cracking with habitual dislocation, and that associated with an abnormality of the interarticular fibrocartilage. Axhausen (5, 6) differentiates the condition according to the time at which the sound occurs—i.e., (1) simultaneously with the opening of the mouth, and (2) at the end of the opening movement. In the former case he believes that the snapping is an indication of the presence of arthritis with associated changes in the interarticular fibrocartilage, while in the latter he considers it the result of habitual subluxation

Treatment

The non-operative management includes rest, the induction of hyperemia by the application of heat and restriction of jaw movement by means of orthodontic appliances. If palliative measures fail, recourse must be had to operative methods directed toward the removal of the cause, e.g , treatment of the habitual dislocation (p 1263), or removal of the abnormal meniscus (34) Dorrance (33) reports satisfactory results from traumatization of the joint surfaces by scratches with a needle

RECONSTRUCTIVE SURGERY OF MANDIBLE

Replacement of Skin

Generally speaking, the mere replacement of mandibular skin offers little technical difficulty The methods used are for the most part similar to those carried out in the restoration of the skin of the cheek and lip In the case of small losses a graft taken from the postauricular or upper palpebral region may be employed provided the base offers adequate nourishment. Owing to the movability of the mandible, however flaps are usually preferred, especially when the loss has been considerable. The neck tissue may often, after the proper undermining be advanced to cover the defect. Because of the flexibility of the neck skin, direct approximation of the margins of the secondary defect is usually possible, and as the incisions can be made to follow natural tension lines the residuary scar will be inconspicuous. A convenient flap is one taken from the submandibular area, the pedicle lying near the angle of the jaw and the free extremity following the curve of the mandible To insure a better blood supply, the flap may be pedicled at both mandibular angles and shifted up over the defect in the form of a hammock (fig 682)

Should skin from the neck be unavailable, a single or double-pedicled transverse scalp flap, so fashioned as to incorporate the superficial temporal artery may be turned down If necessary, the upper part of one or both auricles may be separated to relieve tension (fig 863) Such a flap has little tendency to undergo necrosis, as it contains an adequate blood supply, it can be cut to almost any desired size or shape because of its flexibility it is readily adjusted and for men the growth of hair on the surface of a scalp flap effectually conceals the contrasting qualities of the surrounding tissues and hides the scar The secondary defect left after the removal of either a scalp or a forehead flap is covered with a skin graft, which because of the solid base offered, is almost certain to "take" Another alternative is the use of an arterial flap as described on page 231 If contiguous flaps are unavailable or undesirable, tissues from a more remote part of the body, such as the chest or arm (p 217) may be employed

Replacement of Mucous Membrane

In all but minor losses mucous membrane is replaced with skin in the form of razor grafts (p. 1043) When the mucosa on the floor of the mouth has been destroyed and the tongue is bound down by adhesions, the membrane is supplied by means of an epithelial inlay graft, as follows An incision is made beneath the tongue over the site of the scar, and all cicatricial tissue beneath the surface is removed to form a pocket into which a

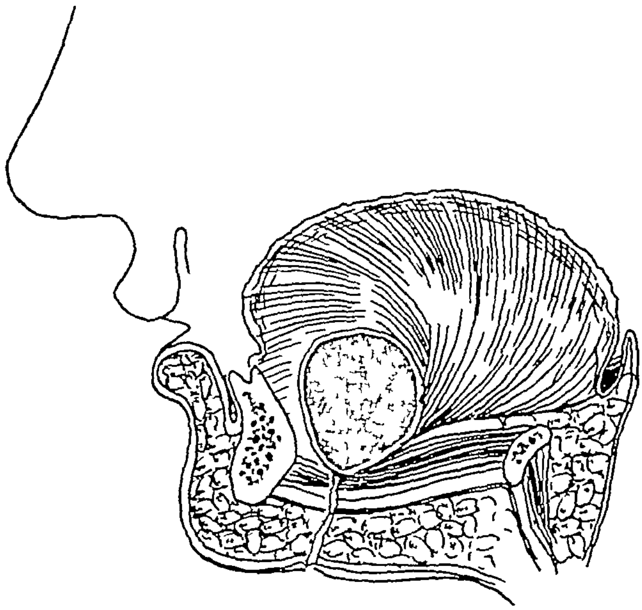


Fig 860 Replacement of mucous membrane on floor of mouth Graft-covered mold introduced into pocket made through submandibular incision After graft has become established, mold removed through intra-oral incision, leaving epithelized surface on floor of mouth (Esser)

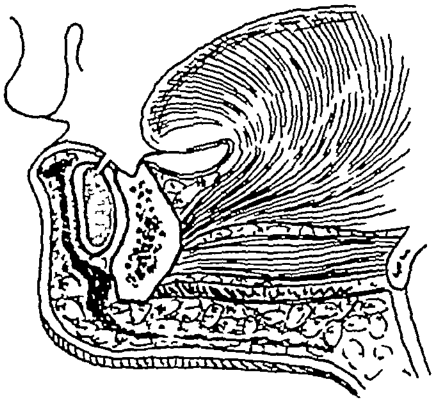
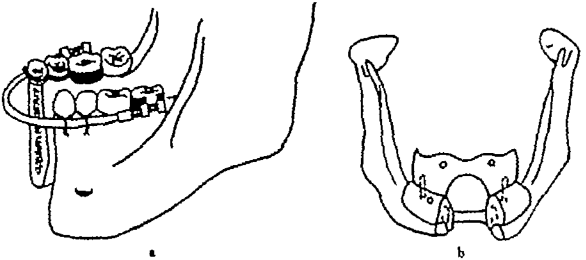


Fig 861 Repair of gingivolabial sulcus. Graft-covered mold introduced through external incision and removed through intra-oral incision, leaving epithelized cavity (Esser)

stent mold covered with a razor graft, raw side out, is buried and sutured in place After 8 days the incision is reopened and the mold extracted The pocket will be found lined with skin, which will serve to replace the lost mucous membrane To lessen the danger of infection, the graft-covered mold may be introduced from the skin surface in the submandibular region and the mold removed through an intra-oral incision (fig 860) The gingivolabial sulcus may be repaired in a similar manner (fig 861) For details of the technic, see page 1071

Reconstruction Following Full Thickness Loss of Mandibular Structures

The first step in the reconstruction of full thickness losses of the mandible is the replacement of cover and lining, the introduction of the supportive structure being postponed until the soft tissues have completely healed in Only by such sequence can a bed capable of supplying the necessary nutrition for the graft be furnished In the interval provision must be made against displacement of the bone fragments by the unopposed action of the muscles and against distortion of the soft parts from cicatricial contraction This is accomplished by means of a splint, the type to be employed depending upon the number, location and stability of the existing teeth. If enough teeth remain to furnish the necessary anchorage, the fragments are maintained in their proper relationship by intermaxillary wiring (p 1208), but should the teeth be insufficient in quantity to permit of wiring, fixation by means of arched bars or band splints must be resorted to (p. 1210) If standing teeth exist in both fragments of the mandible, and the maxilla is edentulous, cast metal cap-splints are cemented to the teeth in each



a b

Fig. 862. Splints designed to prevent displacement of fragments and distortion of soft tissues prior to bone-grafting. *a* Gilmer splint with screw bands. *b* splint for edentulous jaw (Rosenthal)

fragment and bridged by a rigid bar In the absence of teeth in one fragment, a splint equipped with metal caps is cemented to the dentulous fragment and a saddle to the edentulous one, the two being spanned by a rigid bar In the event that both jaws are edentulous, they are fitted with splints patterned after an artificial denture to which flanges of various shapes may be attached for the maintenance of the buccal sulcus and the support of the soft tissues (fig 862)

Replacement of Soft Parts

For the replacement of a total loss of mandibular soft tissue, any of the flaps suggested for the restoration of skin covering may be lined with a razor graft (fig 863) or by a doubling back of the flap on itself The latter method while generally unsuitable in other locations, is particularly applicable to mandibular losses, where a thick flap is desirable for the reception of the graft

A chest flap pedicled on the clavicle and of such a length as to permit of turning of the free end on itself to serve as lining may be used (111) (fig 864) At the first opera

tion the distal end is raised, turned on itself, raw surface to raw surface, the lateral margins are approximated, and the doubled-skin flap thus formed is anchored to the chest as a precaution against contraction The pedicle is gradually extended and tubed

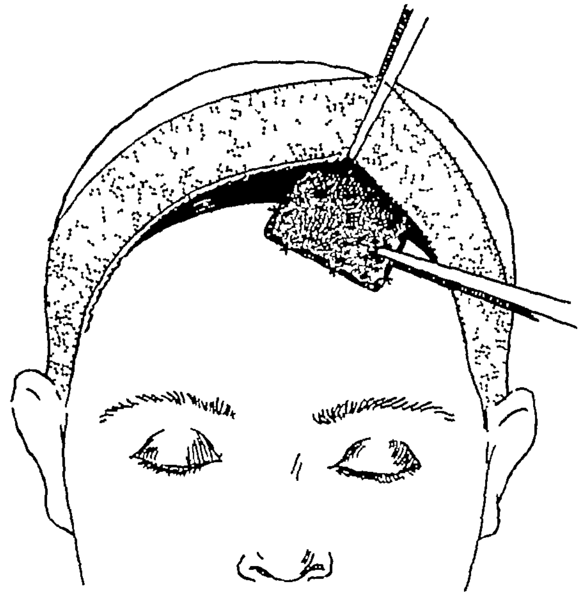


FIG 863 Replacement of lining and cover following mandibular loss by double-pedicled scalp flap lined with skin graft on stent mold, prior to emplacement

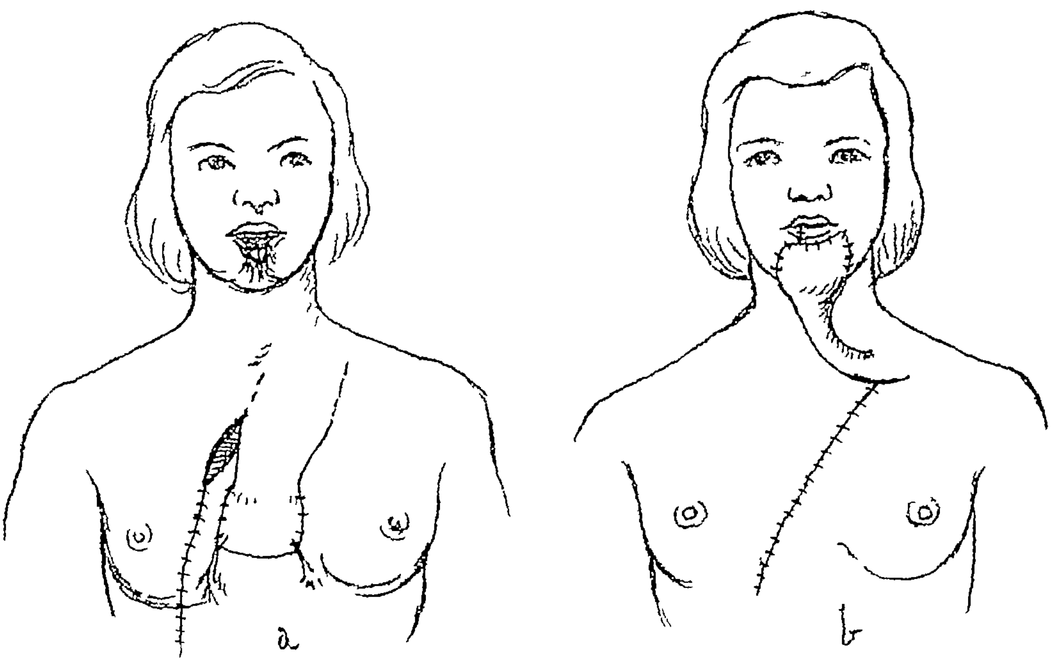


FIG 864 Replacement of soft parts following full thickness mandibular loss by folded-over chest flap *a*, chest flap raised, turned on itself, raw surface to raw surface, to form lining, and lateral margins approximated Flap anchored to chest, as precaution against shrinkage Pedicle gradually extended and tubed *b*, flap swung into defect and sutured in place After vascularization, pedicle cut close to face, and lower part of flap sutured into remainder of defect Stump returned to chest (Voeckler)

at 10- to 14-day intervals thereafter, until it reaches the level of the clavicle The flap is then pared, swung into the defect, and approximated to its revivified margins

A chest-arm flap may also be employed, as follows (fig 865) A flap is raised from the lateral part of the chest and inserted beneath the raw surface of an arm flap to serve

as lining After vascularization has taken place the pedicle of the chest flap is cut, and at the same operation the pedicle of the arm flap is prolonged toward the shoulder and tubed In 2 or 3 weeks the flap is transferred into the freshened defect by approximation of the arm to the head. The parts are immobilized until the flap becomes established in its new location, after which the pedicle is cut, the balance of the flap fitted into the defect, and the arm lowered.

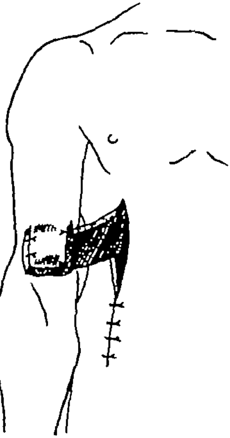


FIG 865 Replacement of soft parts following full thickness mandibular loss by chest-arm flap Arm flap raised and lined with chest flap After vascularization pedicle of chest flap cut close to arm and stump returned to donor site Lined arm flap gradually prolonged toward shoulder and tubed. When pedicle is of sufficient length, flap sutured into freshened defect. Parts immobilized by approximation of arm to head. (Voeckler Klapp)

Replacement of Bony Arch

Replacement of the bony arch is required after (1) the operative removal of benign and malignant neoplasms, cysts, and infectious granulomata, (2) accidental traumatisms, (3) inflammatory states, such as noma and osteomyelitis, and (4) degenerative processes following poisoning from phosphorus and the so-called cancer pastes

Inasmuch as the principal cause of failure in bone transplants is infection, grafting, as previously stated, should not be undertaken until all communications with the mouth have been closed and wounds in the soft tissue have completely healed Septic foci, if present, must be eliminated and 6 months allowed to elapse after all traces of infection have disappeared

Choice of Transplant. Many foreign materials, such as celluloid, magnesium, animal bone and ivory, have been experimented with for the reconstruction of the

mandibular arch, but in view of the ease with which autoplastic material can be obtained and its superiority over foreign bodies, the use of the latter has been generally abandoned

(1) *Flaps* The arch has been restored by means of compound flaps taken from the clavicle (100, 115), rib (92), and frontal bone (9) Theoretically, it would seem that a bone transferred in this manner would have a better assurance of viability than one in the form of a free transplant, inasmuch as flaps carry their own blood supply Practically, however, the vitality of these flaps is limited, owing to the necessarily long pedicle, and this fact, together with the technical difficulties encountered in their construction, has caused them to be supplanted by bone grafts Groves (46) states "In general terms it may be said that these elaborate pedicle operations are obsolete They all involve very grave disadvantages"

Of the flap operations the most practical is that advocated by Cole (27), who separates a portion of the external bony plate from the lower border of the mandibular fragment, leaving it attached by a thick pedicle of soft tissue, and slides it over to fill the gap He operates essentially as follows (fig 866). A skin incision is made below the mandible, extending well into the neck, reaching a lower level in front than behind The flap thus outlined and consisting of skin only is raised to the required level The posterior fragment is exposed throughout its entire extent, but only the extremity of the anterior fragment is bared Through the soft parts clothing the outer aspect of the anterior fragment an incision is now made at a level immediately below the buccal sulcus The basal margin of this portion of the jaw is then sawed off The periosteum on the inner aspect of the fragment is incised The pedicle is then defined by lateral incisions made through the platysma and deep fascia and is gently dissected from the underlying structures The bone is thus freed to an extent sufficient to permit of easy shifting into its new position The posterior fragment is freshened to provide a broad surface contact, and both anterior and posterior fragments are drilled for the passage of a fine silver wire The wires are passed through the pedicle, and around the graft, and, when tightened and twisted, insure snug contact between the graft and the freshened fragments The soft parts are coapted with a few catgut sutures, after which the skin margins are approximated A drainage tube is inserted and retained for 24 hours The splint employed to immobilize the jaw is similar to that utilized for a graft

According to Cole, this transplant has the same biologic qualities as the fragment, vascularization is rapid, and it is possible to detach a thick, well-nourished piece of bone measuring as much as 3 to 4 cm in length, without weakening the jaw Moreover, the operation is easy to perform, and there is not so much danger of infection as in the transfer of a graft But the method is necessarily restricted to the correction of defects anterior to the angle, to losses involving less than 4 cm of bone, and to cases wherein the scar tissue in the soft parts is not so extensive as to interfere with the nutrition of the pedicle Furthermore, it occasions distortion of the soft tissues on the floor of the mouth, and union is not so firm as following the use of a graft, since only the lower margins of the fragments can thus be spanned

(2) *Grafts* Bone grafts for the restoration of mandibular losses may be procured from the ilium, tibia, or rib (43, 63, 80, 98) The *ilium* is the preferable source in the case of adults, because its biologic characteristics most nearly resemble those of the mandible In addition, the osteogenetic properties of a transplant taken from this locality are high, the bone is quickly vascularized, removed without difficulty, leaves

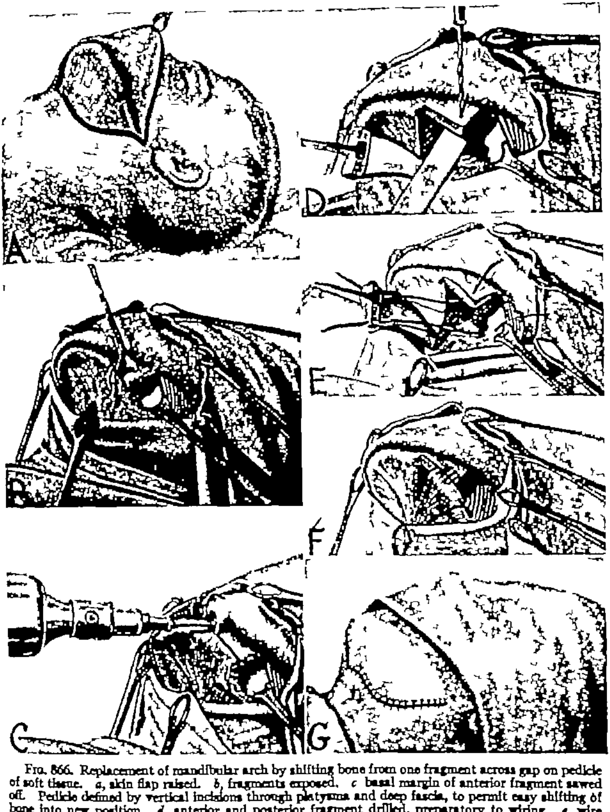


FIG. 866. Replacement of mandibular arch by shifting bone from one fragment across gap on pedicle of soft tissue. *a*, skin flap raised. *b*, fragments exposed. *c* basal margin of anterior fragment sawed off. Pedicle defined by vertical incisions through platysma and deep fascia, to permit easy shifting of bone into new position. *d* anterior and posterior fragment drilled, preparatory to wiring. *e* wire passed through fragments and pedicle of bone flap. *f* graft in place. Wire twisted. Several catgut sutures placed, to obliterate dead spaces. *g*, wound closed. For details, see text. (Cole—Medical Dept., U S. Army., Vol. XI)

no residual disability and can be modeled to any size and shape. Such a graft is especially applicable to the replacement of unilateral losses of the ramus and body In these cases it may be cut in such a manner that the anterior superior spine takes the

place of the condyle, the anterior inferior spine the angle, and the balance of the transplant the body of the bone The technic involved in procuring the graft is described on page 173 The *tibia* is readily accessible, is capable of furnishing a thick block of bone, and provides sufficient stability to maintain the arch, but it is bulky, dense, inelastic, resists the penetration of new blood vessels, and its removal may weaken the leg *Rib grafts* are favored by Gallie and Robertson (41) Morestin (86) advocates the use of rib cartilage, on the grounds that it lends itself easily to fashioning with a knife, promptly becomes acclimated to its new surroundings, and is not absorbed But cartilage does not assure fixity of the jaw, since it will not unite directly with bone Any of the above grafts may be fashioned to simulate the contour of the missing bone by the excision of wedges from the medullary surface and bending of the bone to attain the desired curvature (fig 869)

Osteoperiosteal grafts consisting of a thin shaving of bone, together with its overlying periosteum (32), are especially useful for the replacement of mandibular losses in children and in cases requiring reconstruction of the curve of the symphysis This type of graft contains all the elements necessary for osteogenesis, its removal is easy and rapid and requires no special instrumentarium, it leaves no residual disability, its flexibility permits of easy manipulation, and it assures a broad bony contact But it requires a longer time for consolidation than other transplants, and because of its fragility it cannot be depended upon to maintain the mandibular fragments in their proper relationship during the period of ossification The technic for the removal of such a graft is given on page 177

Attempts have been made to enhance the viability of bone grafts by their implantation into the neighboring soft tissues, where they are allowed to remain until fresh vascular connections have been established, and then transferred into the defect on a pedicle of soft tissue The technic is briefly as follows Three or 4 weeks after all communications into the mouth have healed, a properly shaped graft is inserted through a small skin incision into a previously prepared bed parallel to the lower jaw and extending along a line below the defect During this procedure great care must be taken to avoid penetration into the oral cavity Three or 4 weeks later, when the transplant has become vascularized in its new location, it is freed, together with a generous pedicle of soft tissue, and shifted into the defect (56) (fig 846) Transplantation should not be delayed for more than 4 weeks, however, otherwise, the graft will have become so softened as to preclude effective fixation

In cases where the removal of a benign tumor is contemplated it has been suggested that the bone graft be inserted subperiosteally at the site of the proposed resection 3 or 4 weeks prior to operation, to allow union between the transplant and the mandible (fig 867) The advantages of this method are that the permanent graft is already in place at the time of operation, and the resection can be accomplished without even a temporary destruction of the continuity of the arch For obvious reasons, the applicability of this procedure is limited

Preoperative Preparation of Splints Since immediate postoperative immobilization is necessary for the "taking" of the graft, the splints designed for the purpose must be planned and prepared before operation Frequently, the splint employed to hold the fragments in their normal relationship during the period of soft tissue repair (p 1269) can be utilized Should fixation by intermaxillary wiring be contemplated, the loops are passed during the operation, and the tie wires are placed as soon as the pa-

tient recovers from the anesthetic. If cast metal cap-splints are to be used, they are made in sections and cemented to the teeth preoperatively in such a manner that immediately following the insertion of the graft they can be locked in position (fig 868)

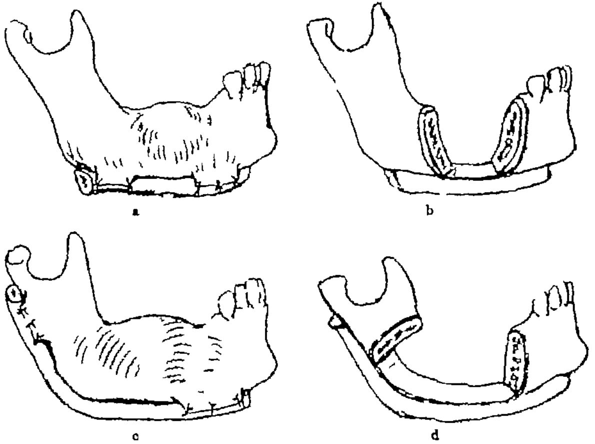


FIG 867 Introduction of bone graft, prior to mandibular resection. *a* and *c*, bone graft introduced subperiosteally at site of proposed resection 3 to 4 weeks prior to operation. *b* and *d* pathologic bone resected. (This permits removal of a portion of the mandible, without temporary destruction of the continuity of the arch.) (Limberg)

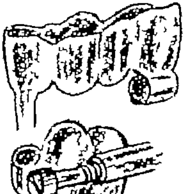


FIG. 868 Fraser's metal cap-splints equipped with screw for immobilization of fragments following bone-grafting of mandible (Kilner)

In cases where both fragments are edentulous, fixation is secured by a firm wedging of the transplant itself between them.

Preparation of Bed for Reception of Transplant. The bed is prepared before the

graft is cut, in order that the size of the required transplant may be accurately determined. Furthermore, should the mouth be inadvertently penetrated, the procedure can be terminated without sacrificing the graft The operation is performed either under general endotracheal anesthesia or with a local nerve-block combined with infiltration

After the parts have been prepared and draped in the usual manner, a curved incision with its convexity downward is made well into the neck. Its length should be sufficient to permit of adequate exposure of the ends of the fragments and the introduction of the graft Frequently, the removal of a pre-existing scar will furnish a convenient avenue of approach The flap thus outlined, composed of skin, subcutaneous

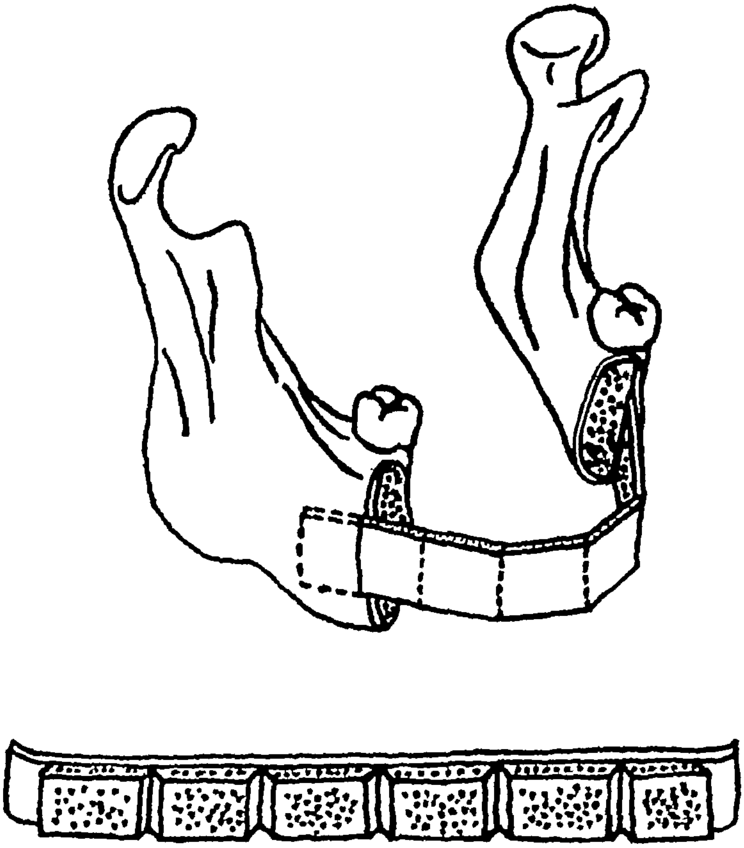


FIG 869 Diagram, illustrating fixation of osteoperiosteal graft in periosteal pockets and method of fashioning graft by excision of wedges from medullary surface

tissue, and platysma muscle, is raised and either fixed to the drapes or held out of the way by means of a few traction sutures Hemorrhage is controlled, and wound cloths are applied to the margins The fragments are then exposed, freshened, and shaped for the reception of the graft Since the baring of the posterior fragment, in view of its greater depth, the attachment of the masseter muscle, and the closely adherent periosteum, incurs more danger of penetration into the oral cavity—an accident which would preclude all further operation—this portion of the bone is therefore freed first With a periosteal elevator the outer surface of the bone is cleared of soft tissue. The dissection is begun near the lower border of the mandible and is carried upward toward the alveolar process and backward toward the vertical ramus The lower border and inner surface are then bared The anterior fragment is cleared in a similar manner

The scar tissue between the fragments is excised. All dissections should be carried out with the least possible trauma and without excessive retraction of the periosteum and soft tissues, since scar tissue is of low grade, and rough handling may lead to sloughing or reactivate a dormant infection If there is considerable displacement of the fragments and a great amount of scar tissue, it may be advisable to remove the latter, splint the fragments in their proper relations, close the wound, and postpone the grafting procedure for a second operation 3 months later

When all scar tissue has been excised the eburnated extremities of the bone are pared with a dental burr driven by an electric engine or with a chisel or rongeur, and are

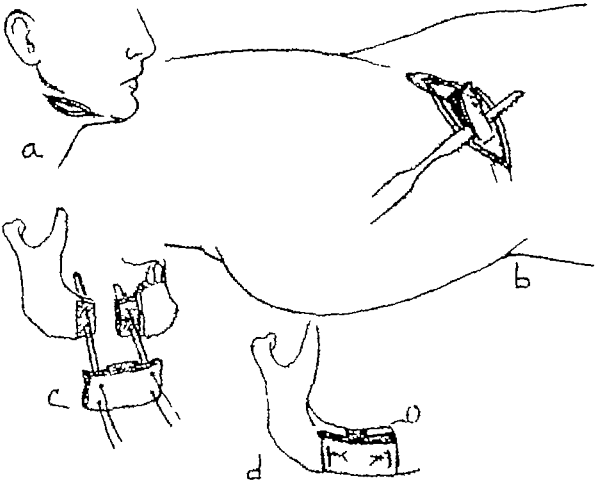


FIG. 870 Reconstruction of mandibular arch with iliac graft. *a* incision made below border of mandible. *b*, graft removed from ilium. *c*, wires for fixation passed through drill holes in fragments and graft. *d* graft fixed in place. (Kilner)

then shaped for the reception of the graft. This part of the procedure is likely to offer technical difficulties, owing to the small size of the bone the restricted field of operation, and the danger of penetration into the mouth The dimensions of the gap are then determined by the use of calipers, and a pattern of the proposed transplant is cut in sheet lead In case wires are to be used for fixation, the points through which they are to be passed are marked out on the pattern.

The further preparation of the fragments will depend upon the method of fixation to be employed. If the graft is to be wedged between the fragments, the ends are beveled or squared (p 179), if it is to be applied to the cortices of the bone, the surfaces

destined to come in contact with the transplant are freshened well into healthy bone and deepened until they bleed freely Two holes 1 cm apart are then drilled through the denuded area of each fragment, and through these apertures a strand of stainless steel wire is passed, the free ends projecting on the freshened surface (fig 870) If the graft is to be embedded in periosteal pockets, the periosteum, without being detached from the soft tissues, is separated from the ends of the fragments for a distance of 1 or 2 cm The wound is then packed with gauze wrung out of hot saline solution

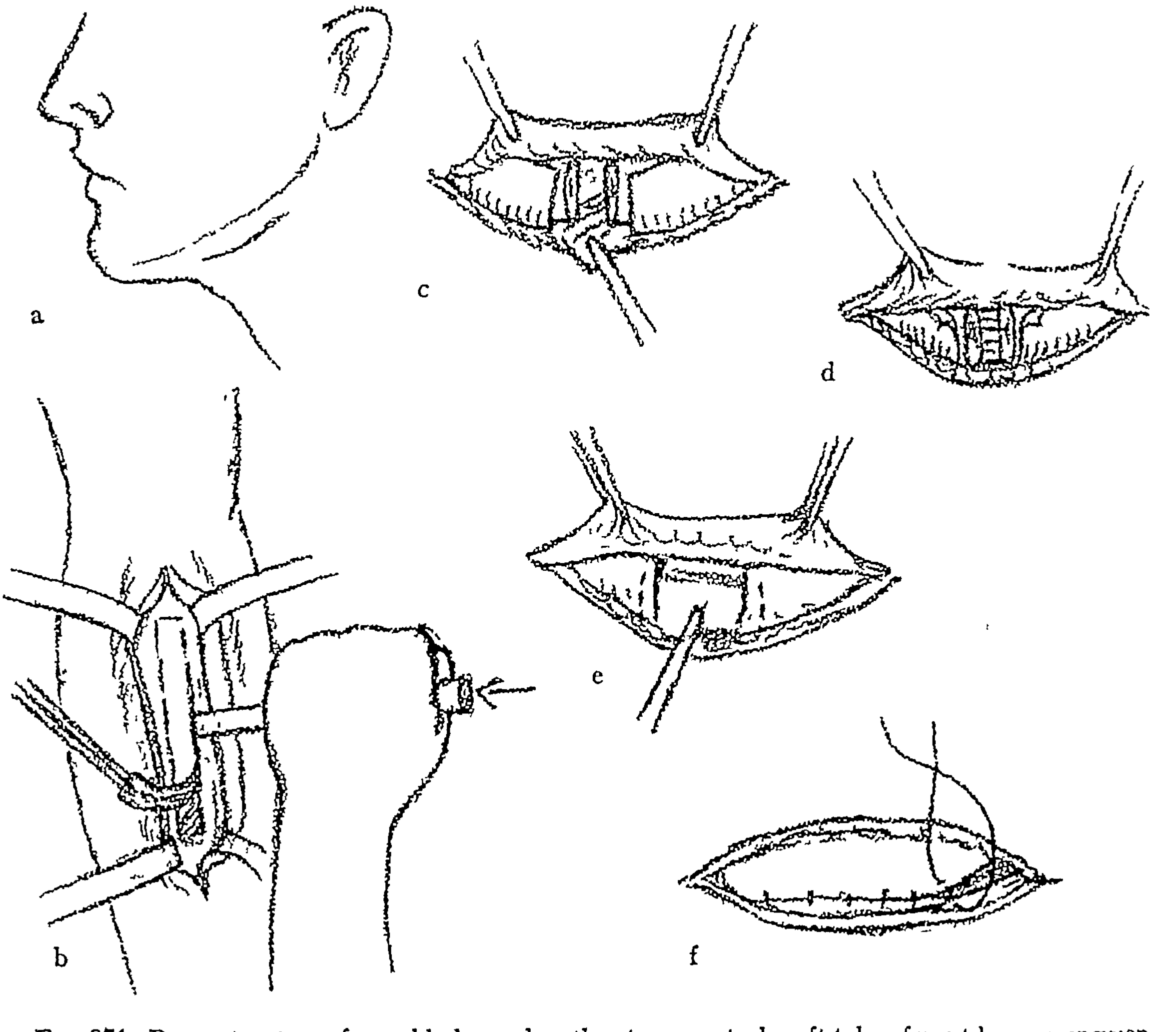


FIG 871 Reconstruction of mandibular arch with osteoperiosteal graft taken from tibia *a*, incision made below mandible for introduction of graft *b*, osteoperiosteal graft removed from tibia according to pattern *c*, portion of graft inserted into periosteal pockets on inner surface of bone *d*, graft in place. *e*, osteoperiosteal graft placed in periosteal pockets on outer aspect of fragments *f*, soft tissue sutured over graft Skin wound closed (Ivy and Curtis)

and the skin is temporarily sutured over it, as a precaution against oozing The procuring of the graft is then proceeded with

Procuring and Placing of Transplant It is advisable that a second surgical team attend to the removal of the graft while the bed is being prepared for its reception This collaboration materially shortens the time of operation and lessens the danger of infection. The transplant is taken from that side of the body in which the defect is located, so that the patient may lie comfortably on one side The selected bone having been bared, the pattern is laid upon it, oulined with drill holes, and the graft removed

with a chisel or a motor-driven saw If the transplant is to be immobilized by wiring, holes corresponding to the points previously marked out on the pattern are bored into it prior to its detachment. Immediately after its excision the graft is wrapped in gauze and placed on a separate table, where it is freed of all muscular attachments and shaped with a bone-biting forceps The residuary wound is closed and dressed in the usual manner

When the graft has been properly shaped, the mandibular wound is reopened, the gauze pack removed, and the transplant, firmly held in a bone-forceps, is placed between the prepared fragments in such a manner that the broadest areas of exposed vascular bone are in apposition. During its insertion care should be taken that it does not come in contact with the skin If wire is to be used for fixation the ends previously passed through the fragments are threaded through corresponding holes in the graft, twisted, cut off short, and bent inward (fig 870-c, d) If immobilization is to be secured by means of periosteal pockets, the ends of the graft are simply slipped beneath the previously raised periosteum (fig 871)

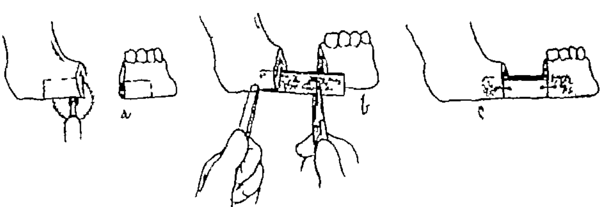


Fig 872 Reconstruction of mandibular arch with rib graft. a, slots made along inferior margins of fragments with motor-driven saw b half of split rib graft wedged, raw side out, into slots c other half of graft placed, raw side in on outer aspect of bone and secured with kangaroo tendon passed through drill holes. (Gallie and Robertson)

Gallie and Robertson (41) immobilize the transplant by wedging it into slots made in the fragments, as follows (fig 872) With a motor-driven saw a cut 3 to 4 cm. deep is made along the inferior margin of each fragment An osteotome is then forced into the saw-cut, and the groove is spread apart. A transplant composed of a section of full thickness rib 7 to 8 cm. long is split flatwise. One section is wedged into the previously prepared slots made in the fragments, its periosteal surface facing the buccal cavity The other section is placed on the external aspect of the bone, so that its medullary surface will face that of the first section The fragments and the graft are fastened in place with kangaroo tendon passed through drill holes.

If an osteoperiosteal graft is to be employed it is procured from the anteromedial surface of the tibia. With a thin Macewen s osteotome held horizontally to the sur face, a section of bone 1 to 2 mm thick 6 to 8 cm. long and 2 to 3 cm wide, together with its overlying periosteum is removed and divided into two or more sections, as required. One piece is embedded into previously prepared periosteal pockets on the inner surfaces of the fragments, its periosteal surface facing the buccal cavity Another segment is similarly inserted on the outer aspect, the periosteal surface facing outward

FIG 873 Reconstruction of mandible destroyed by shell *A*, defect *B*, flaps *a* and *b* outlined, to form upper lip *C*, chest flap including 7 5 cm of clavicle outlined, to reconstruct mandibular loss *D*, diagram, illustrating transference of flap *E*, appearance of flap, after cutting of donor pedicle *F–G*, frontal and profile views, after insertion of cartilage graft, to round out chin (Medical Dept, U S Army, Vol XI)

(fig 871) If desired, a third section may be placed along the lower border of the defect, and a fourth along the upper border, the mandibular defect thus being enclosed by a series of grafts whose medullary surfaces face each other

When the graft has been fixed in position, the deep tissues are sutured in place, the skin is closed, and a pressure dressing applied. Since considerable absorption takes place in the graft before vascularization, the fragments must be immobilized until union is complete This usually requires about 12 weeks. After 8 or 9 weeks the fixation apparatus is removed at intervals, and gentle exercise is prescribed for the stimulation of bone consolidation Progress of the osseous union should be checked by frequent x ray examinations At a later date the missing teeth may be replaced with an artificial denture but before such an appliance can be fitted, the buccal sulcus must be restored. The technic is described on page 1071 The mandibular projection, which is usually deficient following reconstruction, can be filled out by means of either a fat flap taken from beneath the jaw, a fascia lata transplant, or a shaped cartilage or bone graft. Figure 873 shows the reconstruction of a mandibular loss following shell injury

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CHAPTER XVIII

THE SALIVARY GLANDS

ANATOMIC CONSIDERATIONS

During the development of the digestive canal groups of budlike processes destined to become glands grow out from it at several points. One such set forms the salivary glands. In addition, there are many mucous glands, two collections of which on either side require mention One lies on the posterolateral part of the oral portion of the tongue and is called the gland of Weber the other is near the under surface of the tip and is known as the gland of Blandin.

Of the salivary glands the *parotid* is the largest. It is shaped like a three-sided pyramid and is situated on the side of the face, bounded above by the zygoma, below by the angle of the mandible posteriorly by the acoustic meatus and sternomastoid muscle, and anteriorly by the masseter muscle Its facial process forms the angle of the pyramid and lies on the masseter muscle its cervical portion dips beneath the ramus and mastoid process and is located between the pterygoid muscles its upper border is in intimate relation with the temporomaxillary joint, and its base fits against the acoustic meatus. Its outer surface is covered with skin, superficial fascia, and platysma. The gland is enclosed in the parotid fascia (an extension of the deep cervical fascia) which sends trabeculae into its substance, dividing it into lobes and lobules. For this reason, excision of the gland can be accomplished only piecemeal. The outer surface of the fascia is extremely dense, which explains the great resistance offered to the outward progress of a parotid abscess. The suppurative process is more likely to travel either upward to the temporal and zygomatic fossa, downward and forward to the buccal cavity and pharynx, or downward and backward into the neck. Because of the intimate relation of the gland to the auditory meatus and temporomaxillary joint, the infection not infrequently extends into these structures. The unyielding nature of the fascia and the proximity of the auriculotemporal and great auricular nerves explains the intense pain associated with swellings of the gland.

The parotid duct (Stenson's duct) is a musculomembranous tube approximately 5 cm. long and 3 mm. in diameter and is lined with epithelium. It arises from the upper anterior portion of the gland about 1 cm. below the zygoma and runs along an imaginary line between the lower margin of the concha and the vermilion border of the upper lip At the anterior border of the masseter muscle it penetrates the buccinator and opens into the mouth in a visible papilla opposite the upper second molar

The parotid gland is in close relation with many important structures. Within the substance of the gland are (1) the external carotid artery, which enters its deep aspect passes backward and outward, and at the level of the condyle of the mandible divides into its two terminal branches, the internal maxillary and the temporal, (2) the temporomaxillary vein, (3) the facial nerve, lying superficial to the external carotid artery

and the temporomaxillary vein (a line drawn from the stylomastoid foramen to the posterior border of the ramus marks the position of the main trunk of this nerve); (4) branches of the great auricular and auriculotemporal nerves and several lymph-nodes The deep surface of the gland is close to the internal carotid artery, the internal jugular vein, and the ninth, tenth, and eleventh cranial nerves

The arterial supply of the gland is derived from branches of the external carotid, its veins drain into the temporomaxillary, its lymphatics empty into the upper deep cervical nodes, and its nerve supply comes from the facial, auriculotemporal, great auricular, and carotid sympathetic plexus

The *submaxillary gland* is about one-third the size of the parotid and lies in a special compartment of the deep cervical fascia just below and medial to the body of the mandible and anterior to its angle It is composed of a large cervical portion situated in the submaxillary triangle and a smaller buccal division beneath the oral mucosa It is separated from the parotid gland by the stylomandibular ligament and from the sublingual by the mylohyoid muscle Its blood supply is derived from the lingua

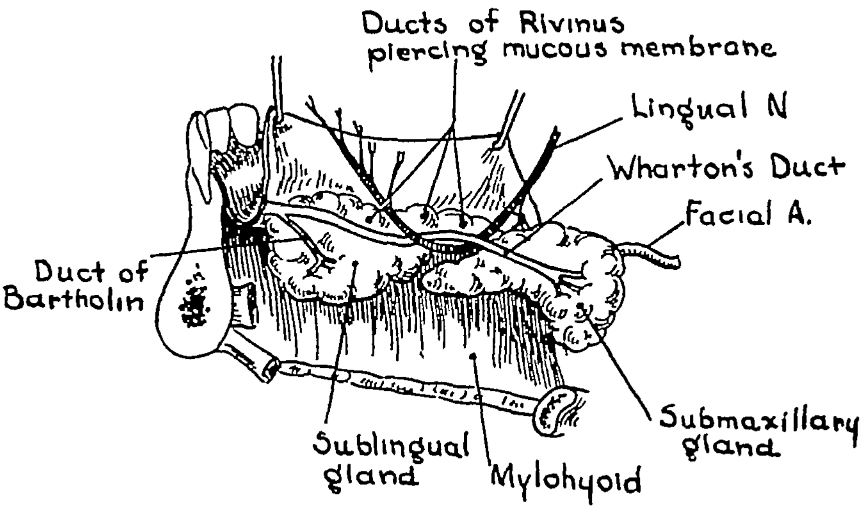

FIG 874 Diagram, showing relation of ducts to submaxillary and sublingual glands (Thompson)

and the external maxillary arteries, the latter running in a groove along its posterior and upper surface, and its nerve supply from the sympathetic and submandibular ganglion The submaxillary duct (Wharton's duct) is 2 inches in length and opens beside the frenum of the tongue (fig 874)

The *sublingual* is the smallest of the salivary glands and secretes a thick mucous fluid It lies on the inner aspect of the symphysis of the mandible, just above the mylohyoid muscle, and forms a long elevation beneath the mucous membrane of this part of the oral floor It possesses about 20 ducts, most of which open directly above the gland, a few, however, opening into the duct of the submaxillary The sublingual and submental arteries supply it with blood, and its nerves are derived from the lingual

WOUNDS

The parotid gland, due to its exposed location, is subject to injury from accidental trauma and operative procedures in the parotid region The submaxillary and sub-

lingual glands usually escape damage because of their hidden position behind the mandible. Wounds in this area are of particular clinical significance, owing to the close proximity of important structures, notably the facial nerve, parotid duct and transverse facial artery A characteristic feature is an external flow of saliva. When the injury is confined to the glandular substance or to only a part of the lateral wall of the duct, the flow, as a rule, ceases spontaneously as soon as healing takes place. But when the parotid duct is completely divided or in the event of infection a permanent fistula may ensue

On the whole, wounds of the salivary glands, unless some important structure has been severed or infection sets in, heal rapidly and may be treated in accordance with general surgical principles (p 265) Bleeding is easily controlled by packing or ligation, except in the submaxillary gland, where hemostasis is rendered more difficult, owing to the circuitous course of the facial artery within its substance. Here occasionally control of hemorrhage can be effected only by a proximal ligation of the facial artery or by extirpation of the gland. When hemorrhage has been checked, the wound is investigated for evidence of injury to the facial nerve and parotid duct. If these structures require no attention and the wound is uncontaminated, the margins are sparingly pared in straight lines and the wound closed in layers, care being taken to approximate the parotid fascia. A drain is inserted as a precaution against the distention of the deeper part of the wound with saliva.

If the facial nerve has been severed and the filaments are not too fine, the ends are sought with an electrode and joined by suturing the epineurium (p 292) In case the parotid duct has been cut an end to-end anastomosis should likewise be attempted. To facilitate suturing, a fine probe or strand of catgut is inserted into the orifice of the duct lying opposite the upper second molar and is made to pass from the divided distal end into the opening of the proximal end. The cut ends of the duct are then united over the probe with fine catgut, all the layers being incorporated in the suture with the exception of the mucosa. Water tight union is unnecessary, since the escape of saliva is of no serious consequence The sound is left in the duct and secured in place by being attached to a tooth The wound is then closed in layers, and free drainage is instituted into the mouth At the end of a week the skin sutures and the probe are removed (8)

In cases where the cut ends of the duct have retracted to such a degree that an end to-end anastomosis is out of the question or when the distal end is obliterated, an effort should be made to carry the proximal end of the duct to the buccal mucosa, to permit the discharge of saliva into the mouth. If this cannot be done, the resultant fistula is treated in the manner described on page 1300

If the wound is seen late or is obviously infected, intra-oral drainage is instituted and closure delayed until all signs of infection have disappeared.

INFLAMMATIONS

Like all glands, the salivary glands are subject to non-suppurative, suppurative, and specific inflammations. The non-suppurative forms are of little surgical consequence and are treated along general conservative lines. The suppurative type, however, while comparatively rare, carries a high mortality It may be acute or chronic, localized or diffuse The acute variety usually attacks the parotid gland and

occurs most commonly in women around the third decade of life Some statistical reports seem to indicate a seasonal predisposition General factors which favor its production are conditions causing a decrease of the salivary secretion, such as dehydration, vomiting, the restriction of fluids following operation, and the use of atropin; local causes include trauma, oral sepsis, and mechanical obstruction of the duct The exciting agent is some variety of pyogenic organism, the staphylococcus, streptococcus, and pneumococcus being the ones most frequently encountered The path by which the infection reaches the gland is not definitely known Probably the most common avenue is the parotid duct (4, 15) In this regard Bucknall (9) states that "one or the other following abnormal conditions must be present· (1) micro-organisms must be present at the orifice of the parotid duct, in larger numbers or of a more virulent type than usual, (2) the general vitality of the subject must be reduced so as to render him more liable to succumb to microbic infection, (3) the quantity of secretion passing down the duct and protecting it must be diminished, and (4) the quantity, and more particularly, the bactericidal proportion of the saliva secreted must be lowered" Less often the carrier is the blood stream, the infection reaching the parotid vessels in the form of septic emboli from acute infections elsewhere (6, 14, 18, 39). Finally, the inflammation may spread to the gland directly from contiguous structures

The onset of the condition is sudden and is manifested by constitutional symptoms of a severe infection and toxemia The gland becomes swollen, hard, and indurated Fluctuation is not easily elicited, on account of the toughness of the parotidomasseteric fascia Intra-oral examination shows the opening of the duct inflamed, and pressure with a probe may evoke a discharge of pus Edema of the face develops early and may be so extensive as to close the eyelid Movement of the jaw is painful, due to impingement of the gland between the bony meatus and the mastoid process As a rule, the facial nerve is not involved

The pus, held in check by the fascia and unable to find exit externally, may spread into the temporomandibular joint or work its way backward between the pterygoid muscles and discharge into the pharynx Occasionally, it spreads upward along the vessels of the neck and enters the cranial cavity In its migration it may erode the carotid artery or the jugular vein, and in view of these dangers, drainage should be instituted at an early date The prognosis is always serious, the mortality averaging 40 per cent (22)

Treatment Because of the gravity of this condition, prophylactic measures assume great importance Oral hygiene should be given due attention and obstructions of the duct sought for and removed In the case of stenosis, Blair and Padgett (4) open the duct and suture the margins to the mucosa of the cheek Postoperatively, efforts should be made to stimulate salivation by requesting the patient to suck lemon drops or chew gum

Once the condition has become established, clinical features rather than physical signs must be depended upon as a guide to treatment, in view of the difficulty in eliciting fluctuation In the early stages the majority of surgeons favor conservative treatment, such as applications of heat or cold, rinsing of the oral cavity with antiseptic mouth washes, frequent catheterization of the parotid duct by means of graded whalebone filiform dilators, and general supportive measures with due attention to chemical and water balance. On the grounds that iodin is eliminated in the saliva, the administration of Lugol's solution has been suggested (28).

If in 2 or 3 days the condition does not subside, the gland is opened and drained The following incisions permit of satisfactory drainage and at the same time avoid injury to the facial nerve and leave a minimal scar If the infection is localized, the opening is made just below the angle of the mandible, and a round nosed forceps is introduced and carried bluntly to the upper pole of the gland. Here the instrument is opened, and the tissues are separated. A drainage tube is then introduced and left in place until suppuration ceases. In the case of diffuse infections exposure is obtained through a vertical incision made in front of the auricle, beginning just below the zygoma and carried down to a point beneath the angle of the mandible, penetrating the tissues as far as the capsule of the gland. The anterior margin of the wound is retracted forward to bare the capsule, which is then split in several places, the cuts being made to run in a horizontal direction as a precaution against injury to the facial nerve. The tissues are separated by means of a blunt nosed hemostat introduced into the gland, a drainage tube is inserted the wound is packed and fomentations are applied.

Rankin and Palmer (39) believe that the morbidity and mortality can be materially reduced by the use of radium packs, and advise that this treatment be instituted as soon as the first symptom appears They attribute the beneficial effect of radium to its action on the infiltrating leukocytes rather than on the infective organisms. Reporting on a case treated in this manner they write as follows "The maximal dose administered was four applications, eight hours in duration, at intervals of eight hours, of four 50-milligram tubes of radium. Filtration was through two millimeters of lead, one millimeter of brass, and 0.5 millimeter of silver, the distance was 2 5 centimeters and the total milligram-hours 6605 The minimal dose used was two applications eight hours in duration, at intervals of eight hours, of two fifty milligram tubes of radium. Filtration was through the same materials as those used in the maximal dose. The total dosage was 800 milligram hours." X ray has also been recommended in doses of 300 R. (41) Desjardins (13) expresses the conviction that the beneficial effects of irradiation lie in the liberation of protective antibodies following the destruction of the lymphocytes.

TUMORS AND CYSTS

Tumors of the salivary glands are not of common occurrence Desaive (12) observed at the Centre Anti-Cancéreux in Belgium between the years 1925 and 1935 that these growths represented only 0 4 per cent of all tumor cases admitted. Of these 80 per cent involved the parotid, 5 per cent the sublingual, and 10 per cent the submaxillary gland. Eighty per cent of the tumors were of mixed type, and the average age of the patient was 45 years.

Benign Tumors

Benign tumors of the salivary glands are rare, the most common varieties being lipoma, fibroma, adenoma, angioma, and lymphangioma. They differ in no essential from benign tumors elsewhere in the body, and with ordinary care they can be enucleated without injury to the facial nerve or gland.

Mixed Tumors

Between the benign and malignant types of salivary tumors there exists a mixed form, characterized (1) clinically by slow growth, encapsulation, and a tendency to local destructiveness without metastasis, and (2) histologically by the presence of all gradations of cells from undifferentiated myxoma cells to highly differentiated tumor formations showing ducts and acini While the most common site for these growths is the parotid gland, they may occur in any part of the mouth—i e , the palate (26, 46), the cheek (17), the lips (37), the accessory nasal sinuses, and the lacrimal glands (10).

Pathogenesis

While no definite conclusion as to the exact origin of mixed tumors has as yet been arrived at, a number of hypotheses have been suggested (1) The endothelial theory attempts to trace their source to the endothelial lining of the tissue spaces This idea, however, has been generally discarded (2) McFarland (30) believes that the theory of "enclavement," or accidental sequestration, of embryonal cells during the complicated development of the face affords the most satisfactory explanation of the origin of these growths He is of the opinion that they are definite entities, having no relation to the normal tissue in which they occur or to other tumors, and that they should properly be called "mixed tumors," irrespective of their histologic nature (3) Other investigators, however, feel convinced that the embryonic explanation is an unwarranted elaboration and that these tumors are true adenomata, their mixed character being more apparent than real Thus Fry (20) states "1 The so-called mixed tumors of the salivary glands are not in reality mixed, but are entirely epithelial in origin They are in most cases derived from the ducts of the gland, but occasionally arise from the secreting cells 2 The mucinous material which is such a prominent feature of most of these tumors is a true secretion of mucin by the tumor-cells, and this is only an exaggeration of a normal function of the gland-cells 3 The tumors do not contain cartilage In the substance which has been described as cartilage, the matrix is formed by a change in the mucin of the tumor, whereby it loses its fibrillar appearance and its power of staining deeply with mucicarmine, the cells are epithelial cells 4 Some of the tumors show varying degrees of malignancy, there is no definite dividing line between the innocent and malignant, and some of the more malignant may show many of the features of the innocent type of tumor " (4) Forgue (19) believes that these tumors are derived from pluripotential cells whose development has been arrested at different stages in the growth of the embryo

Histopathology

The so-called mixed tumors of the salivary glands are encapsuled, slow-growing, smooth or nodular, and of a consistency varying from that of cartilage to jelly They do not become attached to the skin and underlying tissue until they rupture through their capsules Histologically, they are composed of a heterogeneous collection of undifferentiated polyhedral and spindle-shaped cells of varying sizes, showing no evidence of keratinization or mitosis These cells appear around the lymph capillaries either as strands without definite arrangement, or in the form of branching columns and alveoli simulating glandular acini. The stroma is composed of a mucinous, lym-

phoid, nevoid, or chondroid connective tissue, intermingled in various proportions. The findings vary in different sections of the tumor McFarland (30) concludes that there is no relationship between the histologic nature of the growth and its clinical course. Van Vierssen Trip (47), on the other hand, finds that those growths presenting a simple histologic picture have a tendency to remain benign, while those of complicated structure take a more malignant trend.

Symptoms

Although these tumors are inherently benign and as a rule progress slowly, producing no symptoms aside from deformity, statistics prove that 12 to 15 per cent take on rapid growth and become locally destructive. Moreover, metastases to distant structures occasionally ensue (33) The growths range in size from a walnut to an orange and on palpation may be either hard and nodular or soft and elastic. The overlying skin is easily movable and while the growths are attached to the underlying structures, they are less fixed than malignant tumors. Unlike benign tumors they are prone to reappear after removal, the recurrent lesion having a more malignant tendency than the original one. The incidence of recurrence ranges in different series from 15 to 30 per cent (25, 2, 30, 33), the average interval between excision and reappearance being 7 years. Recurrence has been attributed both to failure of complete removal of bits of inconspicuous tumor tissue and to the production of new tumors within the gland. Death is usually due to ulceration, infection hemorrhage, and interference with nutrition

Treatment

All mixed tumors of the salivary glands are potentially dangerous and should be removed early, before they have increased to such a size that their excision would create difficulties (3 49) McFarland (30) however, advises against operation on small growths, claiming that " the smaller tumors recur about twice as frequently as the large ones, probably because the smaller the tumor is, the more apt it is to have very small undiscovered outlying lobules that are left behind at the operation. When the tumor grows larger these also grow, become included in the general tumor mass and are removed with it."

There is a difference of opinion as to the best mode of eradicating these growths. Some surgeons advise excision, others irradiation, and still others a combination of the two Those who favor excision do so on the grounds that the tumor is radioresistant. In this connection McFarland (31) states that such growths when irradiated merely shrink, remain inactive for a time and then resume their interrupted progress. Merritt (32), on the other hand believes that irradiation is the only adequate treatment. He concludes that a combination of this method and surgical extirpation is illogical, inasmuch as if one is sufficient, the other is obviously superfluous.

The technic for the removal of these tumors is the same as that for any benign growth The excision of small superficial growths of firm consistency offers no problem but those which are soft may break down on manipulation, leaving parts of their substance behind which may later cause recurrence while those deeply embedded entail the danger of injury to the facial nerve. As a precaution against the latter contingency, the operation is performed preferably under a general anesthetic, so that the nerve may

be tested with an electrode during the dissection The drapes should be so arranged as to leave the face completely exposed, so that twitching of the muscles can be observed

The incision of approach will depend upon the depth, size, and location of the tumor, but in any case it must be large enough to afford adequate exposure and at the same time not endanger the facial nerve If the growth is localized and superficial, it is exposed through a horizontal incision over the affected site and running parallel to the branches of the facial nerve If the growth lies in the retromandibular fossa near the angle, it is reached by way of an arched incision, convex downward, about 2 cm

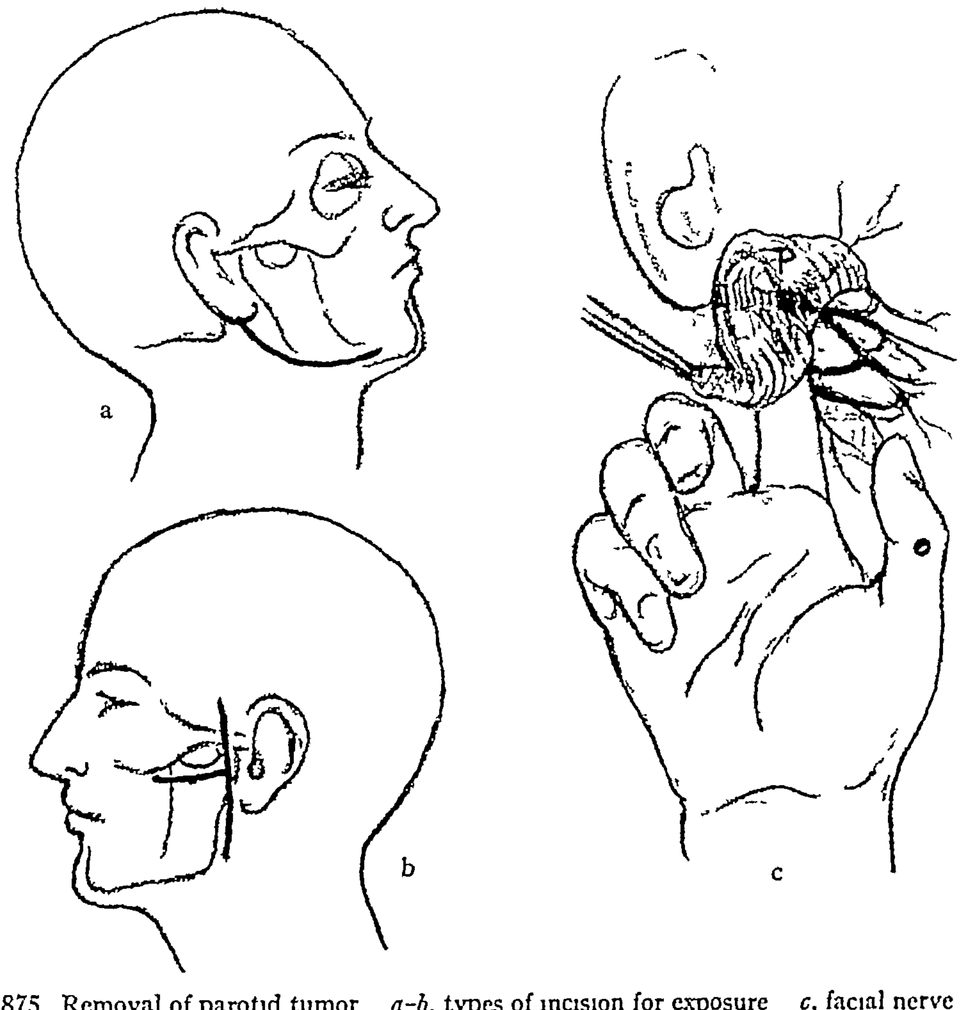

FIG 875 Removal of parotid tumor *a–b*, types of incision for exposure *c*, facial nerve separated from anterior portion of gland Finger kept in front of nerve during dissection, to avoid injury to nerve (Sistrunk)

below the angle of the mandible If the site of the lesion is indefinite, it is sought through a vertical incision in front of the ear (fig 875) After the initial skin incision the fascia is incised in a horizontal direction, to guard against injury to the facial nerve The parts are retracted, and the deeper tissues are bluntly dissected until the junction between the tumor and the capsule of the gland is identified While gentle traction is exerted on the tumor, the gland is separated from it step by step, care being taken to avoid perforation of its capsule (fig 876) Blood vessels are tied and severed as they are encountered Damage to the facial nerve is prevented by a preliminary testing of each strand of tissue with an electrode before cutting Sistrunk (44) avoided injury

to the nerve in the following manner The inframandibular branch of the facial nerve was isolated as it runs around the angle of the jaw beneath the platysma muscle at a point about 1 5 cm. below the angle It was then dissected up through the substance of the parotid gland as far as the division of the facial nerve into the temporal and cervical. A finger was then introduced between the nerve and the portion of the parotid gland which had been lifted from the nerve (fig 875-c) Since the tumor usually lies anterior to the nerve, the enucleation may be carried out in the plane above the nerve. After removal of the tumor and control of hemorrhage, drainage is instituted and the wound closed Some surgeons advise postoperative interstitial irradiation with radium for the purpose of destroying any cells left behind

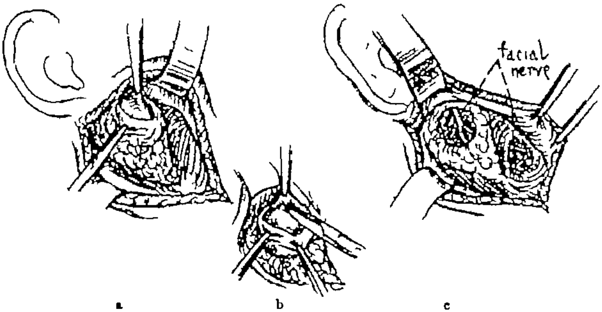

Fig 876. Removal of benign tumor from parotid gland. *a*, skin and platysma muscle reflected Parotid gland incised in direction of fibers of facial nerve. *b* tumor separated from gland with hemostat. *c*, cavity left in parotid gland after removal of tumor showing facial nerve. (Sistrunk)

Malignant Tumors

Malignant tumors of the salivary glands occur more frequently than benign, although they are much less common than the mixed variety They usually take the form of carcinoma, which may be primary or secondary The primary type, as a rule, attacks the parotid gland and the secondary the submaxillary, due to metastases from the tongue Clinically, these growths are either (1) medullary or (2) scirrhous. The former is encountered more often in the young and is characterized histologically by an abundance of cells, and clinically by early ulceration, early invasion of the lymph-nodes, early fixation of the growth to the skin and deeper structures, and marked pain. Symptoms of pressure on the pharynx, esophagus and facial nerve soon follow, and as the disease advances the picture is that of carcinoma of the face (p 1333) The scirrhous type afflicts the elderly and is distinguished by marked fibrosis, the overlying skin being drawn inward and thrown into folds, pain is less pronounced, and involvement of lymph-nodes and metastases to distant structures occur late

As in malignancy elsewhere, the choice between irradiation therapy and surgical removal is a debated question and each case must be judged on its merits If the

growth is small and there is not much infiltration, radical excision of both the tumor and the regional lymph-nodes, preceded and followed by irradiation therapy, offers the best prognosis Applied preoperatively, the rays increase the firmness of the capsule enclosing the tumor and thus facilitate its extirpation, postoperatively they serve to prevent recurrence In more extensive lesions, with considerable infiltration and involvement of the adjacent skin and bone, treatment by irradiation with deep x-ray and radium is the only recourse Quick (38) has found that the medullary variety of carcinoma responds better to radium than does the scirrhous type

Surgical Removal

The growth may be removed under general or local anesthesia If the skin is involved, it is excised together with the tumor through an incision well beyond the diseased area If the skin is not affected, the gland is exposed through a prone T-shaped incision, the vertical limb extending downward in front of the auricle, from a point 2 5 cm above the zygoma to a point well below the angle of the mandible, and the horizontal limb lying below and parallel to the zygoma and of sufficient length to afford adequate exposure of the gland (fig 875-b) The flaps thus outlined are carefully undermined and held out of the way with towels dipped in hot normal salt solution Hemorrhage is arrested With the surface of the growth exposed, extirpation of the gland is begun from below and carried upward This will furnish a bloodless field and permit of the ligation of the large vessels of the neck, thus eliminating the necessity of repeated tying of different parts of the same vessel The external carotid artery with its accessible branches is ligated, and the nodes around the jugular vein are resected The common carotid artery should be preserved whenever possible for the protection of the cerebral circulation, but where the tumor is soft and vascular, the artery may be compressed temporarily with a Crile clamp As a precaution against air embolism, the external and internal jugular veins with their communicating branches are dissected free and cut between double ligatures The gland is liberated by blunt dissection and retracted upward In order to remove its pharyngeal extension, the sternhyoid, stylohyoid, and posterior belly of the digastric muscles, as well as the stylomandibular ligament must be divided The tumor is then carefully freed from the pharyngeal vessels and lateral pharyngeal wall, after which it is separated laterally and above The parotid duct and the transverse facial artery are then tied where they emerge from the anterior margin of the gland If adhesions exist between the tumor and the sternomastoid muscle, the upper part of the latter must be resected Finally, the lower pole of the gland which is attached to the auditory meatus is dissected free, to obtain access to the retromandibular glands, and the upper pole is separated from its attachment to the temporomandibular articulation and the zygomatic arch Drainage is instituted, and the skin flaps are replaced If the tumor is found to have ruptured through its capsule, a more extensive dissection will be required, and the difficulties will be much increased

RANULAE (SALIVARY CYSTS)

The term ranula is loosely applied to chronic, benign, liquid, or semisolid tumors encountered on the floor of the mouth, irrespective of their origin Cysts of a similar

nature often appear in the lip, because of the abundant supply of glands in this location as well as at the tip of the tongue from involvement of the glands of Blandin and Nuhn They may be congenital due to inclusion or displacement of embryonic structures. Some, being lined with ciliated epithelium which normally occurs only in the thyroglossal tract are believed to originate in the glands of Bochdalek, as the latter represent the remains of the thyroglossal tract. More frequently they are acquired in consequence of an obstruction of a muciparous or a salivary gland, the sublingual being the one most commonly affected They appear as slow-growing, fluctuating, painless swellings, bluish-gray in color and covered with a thin atrophied mucous membrane through which the fluid can be seen. Ordinarily, they do not reach great proportions, as the pressure of the liquid contents causes either a degeneration of the secretory epithelium or a rupture of the atrophied mucosa. Occasionally, however, they attain the size of a small orange and cause discomfort by mechanical interference with speech, deglutition, and respiration and in children they may impede the growth of the mandible. If the sublingual gland is affected, the cyst is usually situated to one side of the floor of the mouth but as it grows, it may cross the midline or rupture through the mylohyoid muscle and appear in the neck.

Treatment These cysts can usually be removed intra-orally under local anesthesia obtained by blocking of the lingual nerve The mouth is held open with a gag, and the tongue is pulled to one side by means of a traction suture As an aid to the identification and protection of the submaxillary gland, a probe is introduced into its duct and allowed to remain until the operation is completed.

For a small cyst affecting a mucous gland the best treatment is complete excision of the gland together with the overlying mucosa. A mere emptying of the sac by incision, followed by cauterization of the lining wall is uncertain, since any part of the lining which escapes destruction will cause a recurrence of the growth

When the cyst involves the sublingual gland, the adhesion between the gland and the cyst is usually so dense that enucleation of the cyst without removal of a part of the glandular structure contiguous to it is impossible

Large cysts cannot be dissected out intact, as they invariably rupture, owing to the friability of their walls An incision is made through the overlying mucosa, and the margins of the wound are retracted. The cyst thus exposed is opened, its contents expressed, and the margins of the empty sac grasped in a mosquito forceps With a finger in the sac acting as a guide the membrane is removed by blunt or sharp dissection. It is then carefully examined and any part found to be missing is searched for and removed If doubt exists as to its complete excision the floor is cauterized and the wound packed with gauze and allowed to heal by granulation

If the cyst is so large that its removal would involve a loss of mucosa extensive enough to necessitate a graft the roof is excised and the cut edges trimmed and sutured to the adjoining mucous membrane the floor of the cyst wall thus replacing the normal mucosa of the mouth.

Occasionally, as has been previously stated, a sublingual cyst attains considerable dimensions and extends downward, perforating the mylohyoid muscle and appearing in the neck. These cysts must be approached externally A curved incision is made through the skin, subcutaneous tissue and platysma directly over the tumor This incision should be of such length as to afford adequate exposure and so placed as to

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leave an inconspicuous scar The soft parts surrounding the cyst are dissected away from below upward, until the perforation in the muscle on the floor of the mouth is found If the intrabuccal portion of the cyst is small, the sac may be removed through the neck incision by widening the opening in the muscle, but if it is large, a second incision must be made in the mouth, and the cyst dissected down to the opening in the neck After the removal of the cyst, the incision in the mucous membrane on the floor of the mouth and the perforation in the muscle are closed, drainage is instituted, and the margins of the skin wound are approximated

SALIVARY CALCULI

Calculi may be encountered in any of the salivary glands, they are most commonly found in the submaxillary and least often in the parotid The right submaxillary is involved more frequently than the left (35) Calculi may occur at any age, but they have a predilection for individuals in middle life They are most common in males in the proportion of 2 to 1 Predisposing factors are believed to be defective oral hygiene and conditions that modify the hydrogen-ion concentration and the consistency of the saliva (5, 40) The exciting agent is unknown The calculi are generally believed to be of bacterial origin Soederlund (45) associates them with saprophytic actinomycotic infections He believes that the organism produces a decomposition of the protein of the saliva and a change in the ion concentration, which brings about a precipitation of the calcium salts around the organism In his opinion the so-called Kuettner tumors of the salivary glands have the same pathogenesis as salivary stones An argument against this theory is the fact that horses are subject to calculi but are never affected by the actinomyces fungus Naeslund (34) states that other organisms may cause a precipitation of the salts of the saliva, such as the Wolff-Israel pathogenic strain Wakeley (48) is of the opinion that the presence of foreign bodies in the salivary duct is the initial cause of calculus formation

Salivary calculi range in size from a grain of wheat to a marble and are found either within the gland, the duct, or both They may be single or multiple, rough or faceted They are composed principally of phosphates and carbonates of calcium, combined with animal matter and bacteria In the early stages of their formation and while the obstruction is incomplete, no pathologic changes take place in the gland, but when the canal becomes completely obliterated, cystic degeneration ensues, followed by infection

The symptoms depend upon the dimensions and location of the stone In the early stages the only subjective symptom may be a periodic sense of irritation and mild inflammatory manifestations characterized by a tender edematous swelling in the floor of the mouth along the course of the gland As the calculus increases in size, pain becomes severe and is often paroxysmal, the gland itself becoming noticeably larger A characteristic sign is an increase of the swelling during mastication If suppuration takes place, symptoms of fever and toxemia appear, and the process may terminate in spontaneous extrusion of the stone Intra-oral examination reveals the mouth of the affected gland inflamed and exuding pus on pressure If the stone is in the anterior part of the duct, it can be palpated or detected by means of a Bowman's lacrimal probe passed into the duct Since the composition of the stones is mainly inorganic, they can be readily located by x-ray examination A dental film is placed

between the teeth, with the sensitive side down, the tube below the chin and the rays directed upward parallel to the long axis of the teeth. To increase the visibility of the calculus on the roentgenogram, the gland is displaced downward by pressure of the finger on the floor of the mouth. This manipulation will cause the shadow of the calculus to be cast on the film below that of the bone (23)

Treatment In the absence of symptoms the condition is treated expectantly, since there is a possibility that the calculus will be expelled spontaneously As an aid to extrusion of the stone, dilatation of the duct may be attempted. When inflammation develops, it is relieved by cold or hot applications and antiseptic mouth washes, and as soon as it subsides, the stone is removed, otherwise, the inflammation will recur and may eventually be followed by suppuration and cystic degeneration Removal

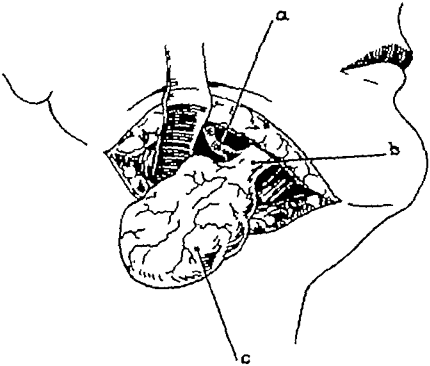

FIG. 877 Extra-oral extirpation of submaxillary gland. *a*, lingual nerve. *b* thickened Wharton's duct. *c* salivary gland (Krause)

of the stone is often a tedious procedure owing to the free mobility of the gland and duct in the floor of the mouth.

The operation is performed under block anesthesia of the lingual nerve If the stone is in the anterior part of the submaxillary duct, the latter is elevated by the exertion of traction on sutures passed through each side of the duct wall. A small canaliculus knife is then introduced into the mouth of the gland, and the duct is slit for a distance sufficient to allow removal of the calculus which is lifted out with a forceps. The opened duct is then sutured to the mucosa on the floor of the mouth and thus converted into an open canal communicating with the mouth (1)

If the stone is in the posterior two-thirds of the duct and is impacted, a general anesthetic is usually required The mouth is kept open by means of a mouth gag and the tongue held out of the way with a traction stitch passed through its substance. While the assistant forces the calculus upward from beneath the jaw, the surgeon fixes

it with a suture passed beneath and behind it Another convenient means of securing immobilization is to press the stone against the mandible An incision long enough to permit of the extraction of the calculus is made along the lateral side of the duct, in order to prevent injury to the ranine artery and lingual nerve which are situated between the duct and the tongue, and the stone is carefully lifted out If further search reveals the presence of additional smaller calculi, they are scraped out with a curet In the absence of infection the incision is closed without drainage, but if there is any inflammation or suppuration, a small rubber drain is introduced

In cases where for some reason extraction of the calculus is impossible, when the gland is fibrosed as the result of prolonged obstruction, or when symptoms persist after removal of the stone, extirpation of the submaxillary gland either intra- or extra-orally must be resorted to (fig 877)

SALIVARY FISTULAE

Salivary fistulae are abnormal communications between the salivary glands and the skin or mucous membrane and arise from breaks in the continuity either of the glands or of their ducts The most common causes are accidental wounds, ill-advised operative incisions in the parotid region, ulcerative processes, such as noma, gumma, and carcinoma, and infections of the glands In rare instances they result from rupture of the proximal portion of the salivary duct, due to obstruction in some part of its course As a rule, they affect the parotid gland and are of surgical importance only when they open externally In the sublingual and submaxillary glands they ordinarily open directly into the oral cavity and require no treatment If the fistula involves the glandular substance or only a part of the duct wall, it has a tendency to disappear spontaneously as healing takes place But if the duct is completely severed, the fistula persists and demands operative intervention, to prevent excoriation and inflammation of the skin occasioned by the constant flow of saliva over the cheek

Treatment

This troublesome condition has given rise to a number of highly ingenious operative procedures, none of which, however, is entirely satisfactory Before treatment is instituted, the fistula should be definitely located, as its site has a direct bearing on the method to be employed For this purpose the duct is probed, or a sialogram is obtained after the introduction of lipiodol, a radiopaque oil containing iodin, 1 cc. of the liquid being injected into the parotid duct by means of a syringe fitted with a modified lacrimal duct needle, and a lateral radiogram taken with a dental film (fig 878)

Fistula within Gland

As has been said before, a fistula within the gland usually heals spontaneously if the part is kept at rest Should it persist, however, and provided the distal part of the duct is unobstructed, the affected portion of the gland may be obliterated by cauterization either with silver nitrate or by means of an electrocautery, followed by the application of a pressure dressing In order that the secretions may be temporarily diminished while healing is taking place, irradiation therapy is instituted

Saborkow (43) advises the following procedure The fistulous opening is excised down to the capsule of the gland. A small incision is made in the skin above and below it at a distance of 2 cm from the circumference of the fistulous tract, and through these openings a purse string suture is passed around the tract with a Deschamps needle (fig 879) When the ends have been tied, the subcutaneous tissue and fascia are automatically drawn over the opening The small skin wounds are then closed with one or two fine silk sutures.

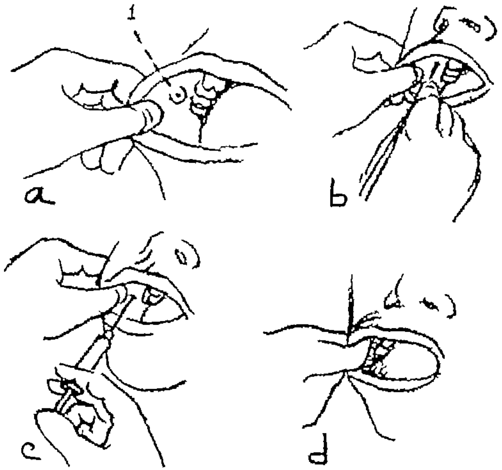

FIG. 878. Visualization of parotid duct by injection of lipiodol. *a* shows orifice of duct on bucca mucosa opposite second upper molar tooth. *b* after cocainization, duct dilated. *c*, needle introduced into duct for distance of 1 cm. and 1 to 1 75 cc of warmed lipiodol injected *d* duct compressed between fingers. (Blady and Hocker)

Fistula within Duct

If the fistula is in the duct at a site anterior to the masseter muscle, an end to-end anastomosis would theoretically be the ideal procedure. Unfortunately, however this is seldom feasible, because as a rule the distal end of the duct is difficult to locate since it has either retracted or become bound down by cicatricial tissue, and even when found the small lumen offers technical difficulties. The aim then is to convert the external fistula into an internal one. Deguise (11) and Kaufman (24) accomplished this by creating a new epithelial tract into the mouth.

Deguise's Operation. A straight needle, carrying a heavy thread or a strand of fine silver wire, is passed through the fistulous opening into the mouth, and the needle with

drawn leaving the suture in place The needle is then rethreaded on the end that projects from the cheek and is passed through the buccal tissue across its previous course, to emerge in the mouth 1 cm from the first needle puncture The loop thus formed will enclose the fistulous tract together with some of the subcutaneous tissue and mucous membrane which surrounds it The ends of the ligature projecting into the mouth are now tied under sufficient tension to cause sloughing of the tissues embraced by the loop, the channel thus formed acting as an artificial duct (fig 880) Following the introduction of the ligature the outer fistulous opening is excised and the wound margins approximated with a subcuticular suture

Glascock and Glascock (21) modify the above procedure and operate essentially as follows (fig 881) A metal probe is passed from the buccal cavity through the distal part of the severed duct, the probe emerging through the wound in the face A thread is then tied to the end of the probe, both ends of the thread being left long The probe

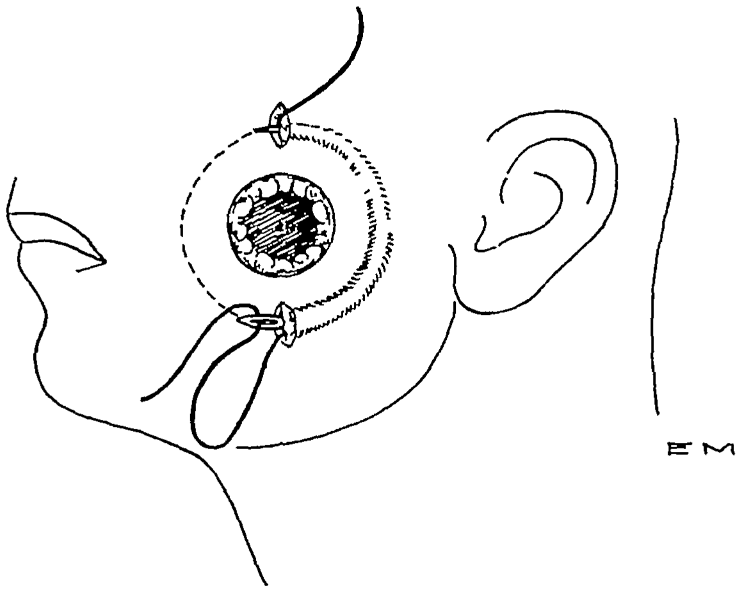

FIG 879 Obliteration of fistula within gland Fistulous opening excised down to capsule of gland Punctures made in skin 2 cm above and below circumference of tract Purse-string suture passed around tract with Deschamps needle When ends are tightened, subcutaneous tissue and fascia are automatically drawn over opening Remaining wounds in skin closed with fine silk sutures (Sabozkow)

is drawn back through the duct, the loop of thread being thus drawn into the mouth The end of a strand of coarse silkworm-gut is bent and hooked into the loop of the thread, which is then pulled back through the distal end of the duct, the silkworm-gut being drawn with it The patient is then given lemon juice, so that the flow of saliva thus stimulated may reveal the proximal end of the severed duct When the latter has been identified, a probe is inserted into the opening, passed to the parotid gland, and forced through its substance Where the probe points, the skin is nicked sufficiently to permit of the probe coming through to the surface, whereupon the thread is tied around it as before and drawn through the proximal end of the duct to the wound. The same strand of silkworm-gut is hooked in the loop of thread, and the thread is drawn through the proximal end of the duct and parotid gland, the silkworm-gut being drawn with it The silkworm-gut now passes completely through Stenson's duct and the parotid gland In order that the silkworm-gut may be held taut, a shot is applied

at each end. Finally, the wound on the face is tightly sutured. The silkworm-gut is left in place for from 4 to 6 weeks.

Kaufman's Operation. A trocar and cannula 0.3 cm. in diameter is introduced through the fistulous opening in the cheek and made to follow as far as possible the course of the duct, until it appears in the mouth. The trocar is removed, a piece of rubber tubing is passed through the cannula into the mouth, and the cannula is removed. Traction is then exerted on the oral end of the rubber tube, until its outer end disappears just beneath the skin. The external opening is closed with the finger,

FIG. 880. Conversion of external fistula into internal one. Straight needle, threaded with heavy thread or fine silver wire, passed through fistulous opening into mouth. Needle withdrawn, leaving suture in place. Needle rethreaded on end projecting from cheek and passed through buccal tissue across its previous course, emerging in oral cavity about 1 cm. from first needle puncture. Ends of ligature projecting into mouth tied under sufficient tension to cause sloughing of tissue embraced by loop, channel thus formed acting as artificial duct. Outer fistulous opening excised, and margins approximated with subcuticular suture. Insert shows course of suture through cheek. (Deguise)

and the patient is requested to chew food. A free flow of saliva into the mouth indicates that the tube has been properly passed. It is then anchored in position intra-orally by means of a silk suture and allowed to remain in place for about 2 weeks, at the end of which time the wall of the newly formed canal will have become epithelized. Should the outer opening fail to close spontaneously, it is excised, the tissues undermined, and the skin edges carefully approximated. If the fistula opens just posterior to the anterior margin of the masseter, the tube should not be carried through the muscle, since the muscular contraction will not only cause pain and trismus, but

will eventually occlude the newly constructed canal Under such circumstances the tube is drawn subcutaneously from the fistula to the margin of the muscle before it is made to puncture the mucous membrane Von Langenbeck (27) diverted the flow

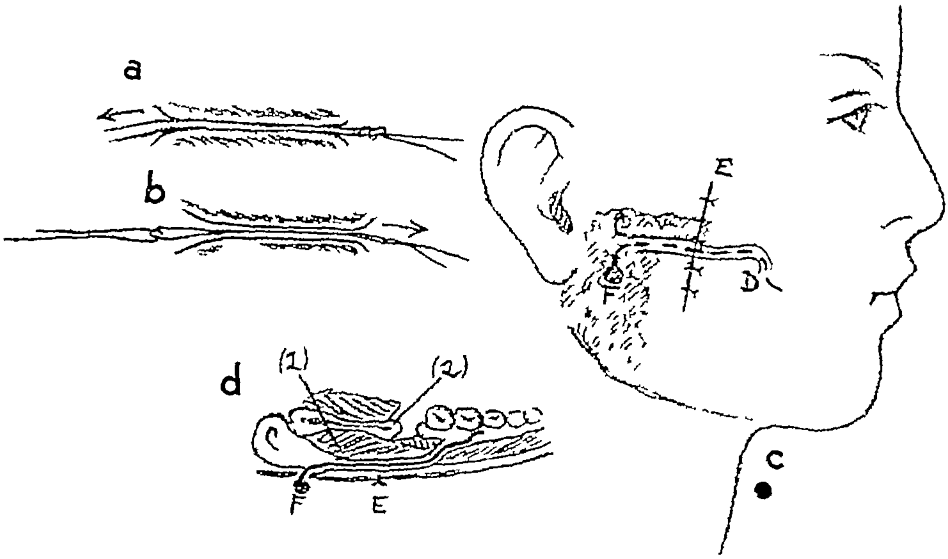

FIG 881 Obliteration of fistula of Stenson's duct *a*, probe passed through duct, and loop of thread wrapped around end *b*, loop of thread drawn through duct into mouth Silkworm-gut hooked into loop, to be pulled back through duct *c*, suture in place *D–F*, course of silkworm-gut through Stenson's duct and parotid gland Shot affixed to end of suture. *E*, external wound sutured *C*, parotid gland *d*, sectional view *1*, masseter muscle *2*, mandible For details, see text (Glascock and Glascock)

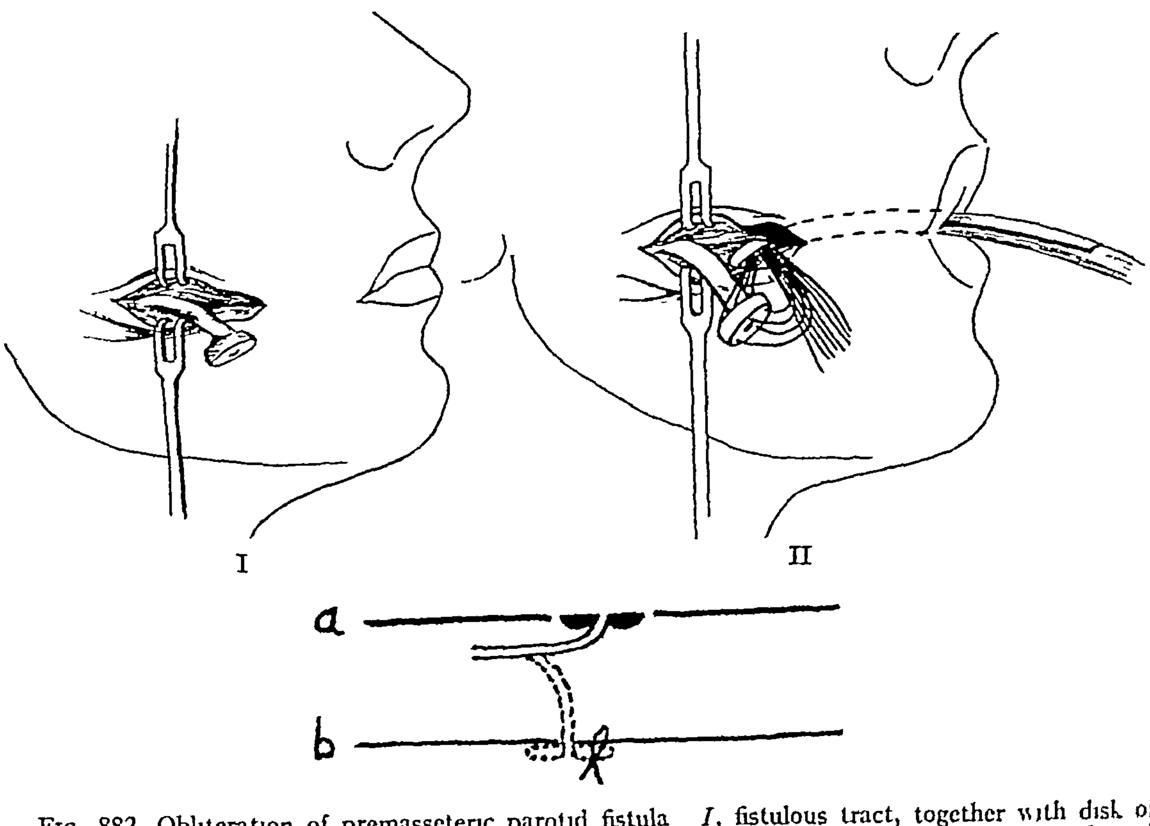

FIG 882 Obliteration of premasseteric parotid fistula *I*, fistulous tract, together with disk of skin 1 cm in diameter, dissected free *II*, duct drawn through buccinator muscle and fixed to buccal mucosa Insert shows sectional view *a*, cutaneous surface, *b*, mucosal surface (von Langenbeck)

of saliva by transplanting the fistulous tract into the mouth, as follows (fig 882) A disk of skin 1 cm. in diameter is outlined around the fistulous opening and this, together with the duct, is dissected free, carried through the buccinator muscle by means of a forceps, and attached to a prepared opening in the buccal mucosa

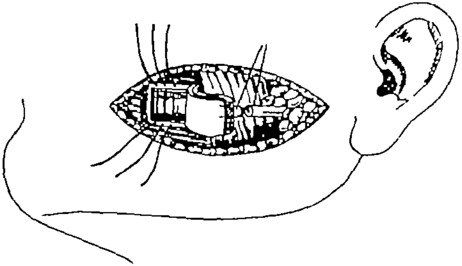

FIG. 883 Obliteration of postmasseteric parotid fistula. Through external incision scar tissue removed. Mucosal flap containing peripheral end of duct (represented by dotted line) turned back over edge of masseter muscle, and ends of duct sutured together (Nicoladoni)

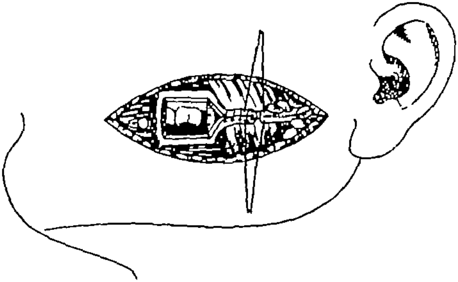

FIG 884. Obliteration of postmasseteric parotid fistula. Flap of buccal mucosa raised, tubed, mucosal side in to reconstruct canal, and attached to proximal end of duct. For details see text. (Kuettner)

If the fistula opens in the masseteric portion the duct is either pieced out with a prolongation of buccal mucosa, or a section of the anterior border of the masseter muscle is removed and the proximal end of the duct implanted directly into the oral mucosa. The plan of piecing out the duct with buccal mucosa was first presented by Nicoladoni (36) (fig 883) Kuettner's technic is as follows (fig 884) A transverse incision is made in the cheek along the course of the duct, all the tissues down to the buccal mucosa being divided The wound is retracted to expose the mucous membrane Two parallel

incisions 1 5 cm apart, enclosing the peripheral end of the fistulous tract, and of sufficient length to bridge the defect are now made through the mucosa and connected anteriorly by a vertical incision The mucosal flap thus formed is turned back over the masseter muscle and sutured to the proximal end of the fistula. The longitudinal margins are then approximated, the flap thus being converted into a tube

Other procedures have been advocated Among these is that of Leriche (29) who advised avulsion of the auriculotemporal nerve for the purpose of diminishing the secretions The operation can be readily performed under local anesthesia through a small vertical incision in front of the auricle The superficial temporal artery is exposed, and the nerve, which is found just posterior to it, is divided and its proximal end cauterized While this is a comparatively simple procedure, it is difficult to rationalize its anatomic basis, since the parotid gland also receives secretory innervation from the sympathetics

Ferrarini (16) has suggested a parotid and submaxillary gland anastomosis. The parotid and submaxillary glands are exposed through an incision just below the angle of the mandible, their adjacent surfaces are denuded and approximated, and the external wound is closed

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CHAPTER XIX

SURGICAL AFFECTIONS OF SKIN

BENIGN TUMORS

The face is a common site for numerous varieties of neoplasms. For convenience of presentation, these growths will be grouped into benign and malignant types, although a sharp distinction is not always possible either from a clinical or from a histologic standpoint.

CONGENITAL VASCULAR GROWTHS

Angioma

Angiomata are growths composed chiefly of imperfectly formed blood vessels and endothelial-lined blood spaces embedded in a framework of fibrous tissue and fat. They may originate in the epidermis, the dermis, or the subcutaneous tissue. It has been estimated that they constitute from 2 to 3 per cent of all tumors and 7 per cent of benign tumors. Females appear to be affected twice as often as males. Usually these growths are present at birth or appear shortly thereafter. Williams found that 83 per cent existed at birth and 12 per cent developed during the first three years of life (112). While they may involve any part of the body, the site of predilection is the face.

A number of theories have been advanced in explanation of the pathogenesis of angiomata. The most widely accepted hypothesis is that of Ribbert, who believed that they originated in a congenital anlage. Normally, the blood vessels arise from contiguous islets of mesodermic tissue which become canalized, coalesce, and subsequently undergo differentiation into arteries, veins, and capillaries. If after the stage of canalization these embryonic units fail to coalesce, the normal anastomotic relationship with the adjacent circulation is not established and angiomata result (44). Because these growths are usually found in areas which in embryonal life correspond to the fissures and because they are frequently associated with other congenital deformities, Virchow suggested as an etiologic factor the displacement of tissue during fetal life. In view of the fact that they so often occur in regions where the fetal skin is naturally under pressure—as, for example, in the forehead and occiput—Unna (115) was of the opinion that they were caused by abnormal intra uterine pressure.

Angiomata exhibit great variations in size, shape, color, number, and surface appearance. In size they range from a pin point capillary loop to lesions involving a considerable part of the body. They are either circumscribed or diffuse, single or multiple. They may or may not project above the adjacent skin, and their surface is either smooth or verrucous. Their color may be uniform throughout or may present a mottled appearance, and varies from a pale pink evident only on exertion to a brilliant

red or purple Their course cannot be predicted with any precision As a rule, they increase rapidly in size until the child is 6 months old, and then remain stationary, enlarging thereafter only in proportion to the growth of the tissues in which they are embedded Occasionally, as time goes on, they become less noticeable, and in rare instances may even disappear altogether, leaving no trace of their former presence In other instances they remain quiescent for a time, then suddenly take on rapid growth, a tumor originally no larger than a split pea spreading over the entire face within a relatively short period, converting the part into a swollen, discolored, mass Moreover, transitional changes are not uncommon, for example, a capillary angioma may become cavernous, fibrovascular, or lipomatous

These growths, aside from producing deformity, damage the contiguous tissues by compression, and by reason of their exposed position are liable to trauma which may lead to troublesome hemorrhage and recurrent inflammatory and necrotic changes Furthermore, when located in areas subject to continued irritation, they are said to develop malignant tendencies Therefore, prompt treatment is indicated, unless they are so situated as to be inconspicuous and not subject to irritation In the latter case, it may be best to disregard them for a time, in the hope that they will remain quiescent A careful watch should be kept meanwhile, however, for evidences of activity, and at the first sign of spreading, inflammation, ulceration, or malignancy, interference is imperative

An adequate classification of angiomata is difficult, inasmuch as the clinical features do not always coincide with the pathologic findings But for the sake of convenience these tumors will be grouped into (1) *a capillary type* and (2) *a cavernous type*

Capillary Angioma Capillary angiomata are composed of a number of superficial dilated capillary vessels lined with several layers of endothelial cells, embedded in fat and surrounded by a connective tissue stroma, the covering layer of epithelium being so thin that the color of the blood is imparted to the growth They appear in a variety of forms Occasionally, the proliferation of endothelial cells within the vessels of the tumor is so great that they form a solid mass which obliterates the lumina of the vessels (compact angioma) Interspersed between these masses of cells are cystic dilatations Being less vascular, they are not so compressible and are paler in color than the ordinary vascular type

(1) *Angioma Simplex (Nevus Simplex)* This is the simplest form of angioma It appears as a faint staining of the skin of the forehead and neck Pollitzer and Depard have pointed out that all newborn infants are to some degree affected by this type of angiomatous formation, but in the majority of cases the discoloration disappears spontaneously within a few weeks Even when it persists, however, it is so pale as to be inconspicuous and requires no treatment

(2) *Angioma Flammeum (Nevus Flammeus, Port Wine Mark)* These growths take the form of non-elevated masses with smooth surfaces Occasionally, they are covered with vascular wartlike excrescences In size they range from a pinhead to a mark covering the entire side of the face and neck Their color varies from pale bluish-red to dark purple, which aptly accounts for their popular name—"port wine marks" They can be completely blanched by pressure with a diascope As a rule, they are limited to one side of the head, appearing at sites of embryonic union It is doubtful whether they ever disappear spontaneously This type of angioma is the most difficult to eradicate without some resultant deformity.

(3) *Arterial Angioma* (*Angioma Vasculosum Nevus Vasculosus, Strawberry Mark Raspberry Mark*) This is the commonest type, and, unlike nevus flammeus, the growths are raised above the skin and are of a bright scarlet color They vary in size and are frequently divided by areas of telangiectatic skin. They grow rapidly during the first few months after their appearance and usually undergo spontaneous retrogression after the first year (70) In rare instances they undergo fibrovascular or lipomatous changes.

Cavernous Angioma. Cavernous angiomata are thick tumorlike growths which often attain great size, producing grotesque deformities. They arise as a result of a direct communication between a capillary angioma and the general circulation. The increased pressure operating upon the defective capillary walls causes them to dilate and break down into a series of communicating blood spaces, through which the blood circulates. These spaces are irregular in shape and size and are united by thin connective tissue septa.

Superficial cavernous angiomata appear as circumscribed or diffuse bluish masses of varicosities elevated above the surface into round or polypoid formations, the overlying skin being atrophied or corrugated, thickened and warty, and over some parts of the growth at times entirely absent. If the tumor is deep, it mushrooms out in the subcutaneous tissue to form a large compressible swelling, the surface involvement giving no indication of its extent. When large afferent and efferent vessels are affected, the tumor may pulsate and give rise to a palpable thrill.

Cavernous angiomata are most commonly found along the distribution of the fifth nerve or on the tongue, and seldom cross the midline of the face. Their color varies from dark red in the superficial type to purple in the deep-seated variety At the outset they are soft in consistency, but in time they become hard owing to the accompanying fibrosis. Spontaneous regression may take place, but more commonly they increase in size until they destroy the surrounding soft tissue by pressure.

A rare form of benign angioma is the so-called glomus tumor, characterized anatomically by tortuous cavernous blood vessels lined with cuboidal cells and surrounded by epithelioid cells having spheroidal nuclei. Clinically, it manifests itself as a small, solitary, dark red elevation, painful on pressure (7, 77)

Lymphangioma

Lymphangiomata are analogous to hemangiomata, except that the malformed vessels and spaces contain lymph instead of blood The lymph channels do not communicate with the adjacent lymphatics. The tumors appear as elevated warty growths ranging in size from a small pea to diffuse nodular masses producing grotesque deformities. They are yellow in color when they contain lymph vessels and reddish or purplish when small blood vessels are intermingled with the lymph channels (angiolymphangioma) The face, neck, lips, and tongue are the parts most commonly affected. On the tongue the enlargement produces one type of macroglossia on the lips, macrocheilia, and on the neck, cystic swellings known as cystic hygromata. As a rule, lymphangiomata remain quiescent, but, like hemangiomata, they may at any time take on rapid growth.

The classification of lymphangiomata offers the same difficulty as that of hemangiomata, but owing to their similarity they are also grouped for the sake of convenience

into a *capillary* and a *cavernous* variety. *Capillary lymphangiomata (lymphangioma simplex)* are characterized by poorly defined proliferations of lymphatic vessels. They appear as circumscribed swellings in the skin and subcutaneous tissues, varying in color from dull yellow to brown, and can be partly effaced by pressure Their surface is either smooth or verrucous The *cavernous type* (*lymphangioma circumscriptum*) consists of a framework of connective tissue containing numerous discrete or communicating spaces, within which are irregular masses of lymphocytes and neoplastic blood vessels The lymph spaces may break down and coalesce to form cystic tumors. The most serious complication associated with these growths is infection, which is difficult to eradicate because of the defective lymphatic nodes

Management of Angiomata

Inasmuch as these tumors are usually located in conspicuous areas and are essentially benign, a good cosmetic result is an important consideration. Their eradication is effected either by extirpation or by an occlusion of their vessels by physical means All forms of treatment entail a certain degree of scarring, with the possible exception of irradiation with radium or ultraviolet light, which occasionally effects a complete disappearance of the growth Unfortunately, no one method is equally effective for every type of angioma The problem is to choose the modality which will eradicate the growth and at the same time leave the least residual deformity. Consideration must be given to the pathology, location, size, and depth of the growth, as well as to the patient's age and the clinician's experience with the particular method to be employed. Frequently, the desired results can be brought about only by a judicious combination of two or more procedures

Surgical Excision. Surgical excision is superior to irradiation, in that it does not involve a lengthy and expensive course of treatments, and it is preferable to the introduction of sclerosing solutions and to cauterization, since it leaves a linear scar instead of a slough Unfortunately, however, the size and location of the growth are usually such as to prohibit primary surgical excision Such a procedure is practicable only (1) when the growth is small enough to permit of a direct approximation of the wound margins after its removal If the tumor is so large that after excision the remaining defect would necessitate resurfacing with a skin graft, the final result would be likely to be little less conspicuous than the original condition (2) When the angioma is not in the vicinity of important structures, such as the facial nerve, external maxillary artery, or parotid gland, which might be damaged during the procedure (3) As a supplement to, or in combination with, other forms of treatment—for instance, for the removal of conspicuous or epitheliomatous scars, pigmented areas, or distortions left after the destruction of an angioma by radium or electrocoagulation. Frequently, surgery may be employed to advantage after the angioma has been reduced in size and the danger of hemorrhage has been diminished by irradiation.

The chief difficulty in the removal of these growths, especially if they are of any considerable size, is that involved in the control of hemorrhage, which is commonly profuse because of the vascular nature of the tissues Before the patient is subjected to operation, his blood should be matched, and throughout the procedure a donor should be kept in readiness in case of need Bleeding will be somewhat minimized if prior to operation the blood vessels are transfixed by means of interlocking buttonhole stitches

passed around the tumor (fig 220) As a further safeguard against bleeding the main vessel supplying the tumor may be ligated During operation, as an additional precaution, the assistant is requested to exert digital pressure over the soft tissues against the bone on either side of the proposed incision, or to press a flexible lead wire loop into the skin around the tumor (fig 885) Despite these precautionary measures, however, hemorrhage is at times alarming and difficult to check.

The growth may be excised either under general or under local anesthesia. In the latter case the infiltration should be kept at a safe distance from the field of operation.

Whether the tumor is to be removed in one or in several stages will depend upon its size and location. If it is small enough and so situated as to permit of direct approximation of the wound margins following excision, or if the raw surface is to be covered with a skin graft, the operation is best completed at a single sitting, otherwise, gradual, partial excision of the growth in two or more stages is preferable.

If the entire growth is to be removed at one sitting, the incision should be planned in such a manner as to allow the most advantageous closure with the least conspicuous

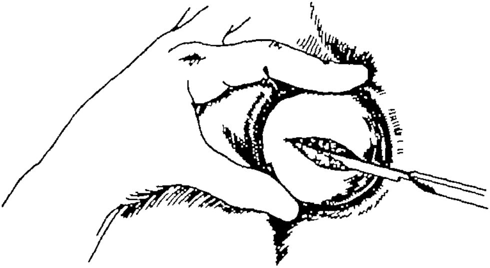


FIG 885 Control of hemorrhage by pressure of flexible lead wire loop against skin.

scar This is best accomplished if the area to be excised is first marked out with a dye, the outline assuming the form of an ellipse and following so far as possible, the normal tension lines of the skin (p 51) With this pattern acting as a guide, the tumor is then encircled by two arched incisions meeting at their extremities. If the angioma is limited to the skin, one point of the outlined area is picked up with a toothed forceps and the affected skin is gradually dissected away from the subjacent tissues. If, however, the growth involves the subcutaneous structures as well, the incision is deepened to the level of the base of the tumor, and the entire mass is removed To assure against recurrence, it is essential that no part of the growth be left behind. As previously stated, hemorrhage is usually copious, and attempts to control it by the use of hemostats is ineffectual, as the instruments tend to tear through the friable tissues. A more satisfactory procedure is to run a whip stitch around the angiomatous mass and tighten it sufficiently to compress the vessels. If the wound is to be closed directly, the skin margins are undermined until they can be approximated without tension If necessary the contour is reconstructed by means of fat flaps turned in from adjacent

areas (fig 920). The subcutaneous tissues are then united in layers with buried sutures of fine silk, and the skin is coapted either by means of a subcuticular suture of silk or on-end mattress-sutures of horsehair Finally, a pressure dressing is applied (p 124). The stitches are removed on the second or third day.

The details of the technic for the removal of the tumor in several stages is described in detail on page 1373 Briefly, an elliptic section of the tumor large enough to permit of immediate approximation of the wound margins is removed The wound is closed, and after a sufficient interval has elapsed for the tissues to regain their pliability, another section is removed in a similar manner. Two or three such operations usually suffice to eradicate the entire growth (fig 919)

The excision of a facial angioma is sometimes followed by a paralysis of the facial muscles, owing to stretching of the nerve fibers This is no cause for alarm, however, since spontaneous recovery usually takes place within a few days

Radium Therapy. Radium is capable of giving excellent results when employed in the treatment of angioma and occasionally causes the growth to disappear without leaving a trace of its former presence The earlier this therapy is instituted, the more promising is the outcome, since the sensitivity of endothelial cells to radiation decreases with age Figi (40) states that at the Mayo Clinic no agent has been as satisfactory as radium in the case of angioma in children. The chief drawbacks to its use are the difficulty of controlling the infant and of obtaining an even distribution of the rays over the affected area, especially when the growth is located in the vicinity of irregular contours, such as the eyes, ears, nose, and lips. There is also the danger of interference with growth and the possible development of malignancy In any case, radium should be administered only by one skilled in its use, since the amount required is subject to wide variations and calls for careful individualization based upon the location, size, elevation, and depth of the lesion, the age of the patient, and the sensitivity of the particular skin An error in judgment regarding dosage or screening, or an inadvertent overlapping of the field may give rise to a radiodermatitis, characterized by atrophy, scarring, pigmentation, blanching, sclerosis, and telangiectasis

Although it is impossible to lay down precise rules regarding the amount of radium required, the duration of its application, and the degree of screening, generally speaking these factors vary in direct proportion to the depth of the lesion As a rule, the best results are obtainable from small doses given over prolonged periods The applications must not overlap and must not extend beyond the surface limits of the growth, nor should they be repeated at shorter intervals than 6 to 8 weeks Special care must be taken in the treatment of those patients who have been previously subjected to other forms of therapy.

Radium may be administered (1) as a surface pack, (2) in tubes applied to the surface of the lesion, and (3) in needles or as radon seeds implanted in the tumor Figi (40) treats capillary angioma by the application of radium plaques containing from 5 to 25 mg of radium element The plaque is covered with a rubber finger cot and is kept in constant and uniform motion over the surface of the growth for from several minutes to an hour or longer, depending upon the size of the lesion Figi states that "other factors being equal, the plaque containing a smaller amount of radium element used for a long period as a rule produces a more satisfactory cosmetic result than the plaque containing a greater amount of radium element used for a short period." For cavernous

angioma appearing in early childhood he recommends the use of a radium pack, the dose ranging from 2000 to 3000 mg hours The application is repeated at intervals of 3 to 4 months, the number of treatments being governed by the individual response. In the case of adults Figi claims that as a rule such lesions can "be taken care of more satisfactorily by electrocoagulation or excision, with or without ligation of the efferent and the afferent vessels In addition, radium needles or small tubes containing small amounts of radium are inserted directly into the tumor the thread alone remaining visible. One to six or more [needles] are implanted for periods of several hours, depending on the situation and extent of the growth and whether or not it has been treated previously"

Brown (14) treats these growths with gold radon seeds introduced in such a manner as to allow an equal volume of tumor tissue to each seed. The introducing instrument is a hollow needle fitted with a plunger for the expulsion of the seed. In small lesions about the eyelid, nose, lips, and ears he suggests seeds of 0 25 millicurie, for large tumors in other areas, from 0.5 to 1 millicurie The total dosage is calculated as 1 radon seed per cc. of tissue to be irradiated.

MacKee (74) treats superficial lesions with beta rays obtained from ½ strength glazed radium element applicator screened with $\frac{1}{10}$ mm. aluminum placed in contact with the lesion for 10 to 20 minutes For large deep lesions he employs heavily filtered gamma rays placed at a distance His technic is as follows "A tube containing 50 millicuries of radon (radium emanation) filtered through 0.5 mm. silver, 1 mm. brass and 1 mm. aluminum, placed at a distance of ½ inch from the surface, may be used for one hour over each square inch of the lesion."

Sclerosing Solutions. The success obtained from sclerosing solutions in the treatment of varicose veins has led to their use for the eradication of angiomata, and the results have been found so satisfactory, especially in growths of the cavernous type, that these solutions are fast replacing other modalities. The method is inexpensive, simple, and rapid, requires no complicated equipment, and allows the patient to remain ambulatory However, it entails the risk of sloughing scarring, infection, embolism, and thrombophlebitis.

Numerous sclerosing solutions have been advocated Andrews and Kelly (5) recommend 20 per cent quinin hydrochlorid and ethyl carbamate, sodium chlorid and 50 per cent dextrose solutions Light (68) employs 30 per cent sodium salicylate and invert sugar Kaessler (61) reports successful results with 20 per cent quinin dihydrochlorid and urethan diluted with an equal part of 2 per cent procain hydrochlorid (with epinephrin) He injects the solution 'through a 26 gage short bevel security type hypodermic needle along radial paths from a single injection site This needle has a metal bead incorporated in the shaft adjacent to its attachment to the hub It allows the needle to be easily retrieved if broken A half cubic centimeter vaccine or tuberculin syringe allows accurate control of the solution injected. The needle is so directed that the solution is initially injected superficially throughout the mass. From 0 1 to 0.2 cc. is injected at a time Immediate blanching of the area occurs about the needle point. The needle is then advanced and the next injection is placed so that its area of blanching is contiguous with the previous one Multiple areas are thus injected until the entire lesion has been mottled with areas of blanching The point chosen for injection often bleeds, but a few minutes pressure with gauze or a drop of

collodion will seal the puncture If the lesion is very irregular in outline or its diameter is greater than the length of the needle chosen, other injection sites may be chosen A small gauze pad is applied firmly over the entire injected area with adhesive tape The dressing is removed after from forty-eight to seventy-two hours and the area left exposed"

In 1902 Wyeth (128) suggested the use of *boiling water* for the destruction of angiomata, on the grounds that the heat destroyed the endothelial lining of the blood vessels composing the tumor and caused thrombosis of their contents The method at first found many advocates (98), but because boiling water has no advantage over other sclerosing solutions and is difficult to handle, it has since been largely supplanted by other agents The technic is as follows. A cold moist towel is laid over the tissues surrounding the tumor, as a precaution against burning Two to 5 cc of water at a temperature of from 180° to the boiling point are slowly injected into the angioma with an all-metal syringe, the hands of the operator being protected by thick rubber gloves As soon as the area becomes moderately distended or the skin appears blanched, the injection is discontinued and the needle is removed and reinserted at a point 1 to 1 5 cm farther away Care should be taken to avoid overdistention, as this may lead to sloughing and considerable scarring Similar injections are made at equal distances from one another until every part of the tumor has been reached The extensive inflammatory changes resulting from this procedure are controlled by the application of cold compresses If necessary, the treatment can be repeated in 2 or 3 weeks

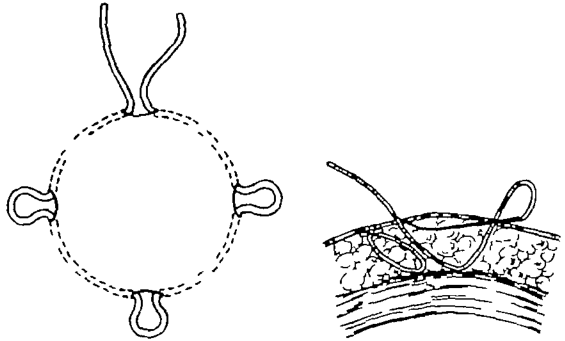
The introduction of *magnesium* into the angiomatous mass was suggested by Payr on the assumption that the oxygen of the tissues would combine with the magnesium, and the subsequent liberation of hydrogen would cause a coagulation of the blood in the tumor Needles of metallic magnesium 1 to 1 5 cm long and 2 mm wide are sterilized in boiling water and then forced through the skin into the tumor.

Electrocoagulation. The employment of high frequency currents (bipolar high frequency current of the d'Arsonval type) to bring about electrocoagulation of the tumor mass is the preferred method for the eradication of cavernous angioma in adults, provided the growth is not in the vicinity of important structures The current renders the operative site aseptic and does not char the tissues, the procedure is accompanied by no bleeding and little pain, healing is prompt, and the resultant scar is of good color and does not tend to contract unduly The chief difficulty lies in gauging accurately the intensity of the coagulating process Occasionally, despite all precautions, only moderately intensive therapy will be followed by sloughing, necessitating a long series of plastic repair This untoward sequela is especially prone to occur in angiomata that have been previously treated by irradiation

In large cavernous angiomata, especially those with an expansile pulsation and a palpable thrill, it is well to precede the electrocoagulation, when feasible, by ligation of the afferent vessels which supply the tumor Simple methods of subcutaneous ligation are illustrated in Figure 886 The technic of coagulation with the endotherm needle is simple If the skin over the tumor is healthy, the needle is inserted directly into the growth, but if it is thin, it is introduced through the healthy area adjacent to the mass In either case the shaft is directed obliquely, so that the several punctures will meet at a common point below the tumor When the needle has been inserted to

the required depth, the coagulating current is turned on and its flow continued until a slight blanching or change of color appears in the skin adjacent to the electrode. The current is then turned off and the needle withdrawn. Multiple areas at points 1 to 1.5 cm. distant from one another are thus coagulated until the entire growth has been treated. The surface is smeared with a thick coat of sterile boric acid. Within 24 hours the part becomes swollen, and an extravasation of a serosanguinous material takes place, eventually forming a crust. This is followed by cicatrization, which gives the tumor a lobulated appearance.

The subsequent management will depend upon the size of the growth and the amount of tissue coagulated at each operation. As a rule an interval of 6 weeks should be allowed to elapse between treatments. The scar which remains can be minimized by the application of filtered x rays, or it may be entirely removed by a plastic operation.



a b

FIG. 886. Circumferential subcutaneous ligation, to cut off blood supply of angiomata. *a*, single purse-string suture. (Binnie) *b* multiple sutures. (Krogius)

Cauterization. Cauterization may be resorted to in the treatment of capillary angiomata when excision is impracticable or when irradiation is unavailable. The most popular agents used for the purpose are (1) carbon dioxid snow, (2) trichloracetic acid, and (3) the electrocautery.

(1) *Refrigeration by Carbon Dioxid Snow.* Carbon dioxid snow has a non-selective destructive effect upon the tissues and acts by producing a "frostbite" which leads to sloughing followed by cicatrization. Its use is limited to the treatment of capillary angiomata less than 2 cm. in diameter which project above the skin and do not involve the subcutaneous tissues. It leaves a thin slightly depressed white scar somewhat larger than the original lesion and resembling the cicatrix that results from desiccation. For deeply embedded angiomata this agent is contraindicated, since an application of sufficient strength to effect obliteration of the growth would result in a depressed scar more conspicuous than the original lesion.

Carbon dioxid snow is easily obtained from tanks such as those in commercial use A spray of the gas is permitted to play into a bag of chamois leather The snow, which forms immediately, is pressed into a pencil-shaped mold of wood or metal and stamped down firmly. The snow crayon thus constructed is then removed from the mold and wrapped in cotton wool, 1 cm of its substance being left to protrude beyond the wrapping The projecting end is tapered with a knife, so that it may be conveniently applied to the nevus In order to guard against freezing the adjacent healthy skin, a pattern of the angioma is made in cellophane, laid on a piece of cardboard, and cut around The cardboard frame thus constructed is placed over the growth while the freezing agent is being applied

With the part firmly supported and the protective collar in place, the point of the snow crayon is applied to the tumor with a firm even pressure The destructive effect of the agent upon the tumor is in direct proportion to the length of time the pencil remains in contact with it and the pressure with which it is applied A period of 5 to 20 seconds produces a slight reaction, and 30 seconds a moderate reaction, while 60 seconds is the limit of safety

Ordinarily, the crayon is applied at a pressure of about 1 pound over a period of 5 to 20 seconds, depending upon the depth of the growth If the mass is a large one, several applications will have to be made, and under such circumstances care should be taken that the areas that have been thus refrigerated do not overlap, otherwise, a mottled cicatrix will result. Immediately after the treatment the tissues become white and are depressed below the surface Thawing takes place in about 3 minutes and is associated with considerable pain An inflammatory reaction soon follows, resulting in the formation of vesicles and bullae which in time rupture to form a crust This crust should not be disturbed, lest the trauma occasioned by its removal lead to a hypertrophic scar It will separate spontaneously in approximately 10 days, and it is then that the extent of the destruction will become apparent

Several treatments may be required for the complete eradication of the tumor, especially if it presents a considerable elevation above the plane of normal skin Subsequent applications require careful judgment in timing the dosage and the amount of pressure, and here the surgeon must be guided by the results obtained from the previous treatment It is better to use moderate pressure and short exposure and repeat the process, than to resort to more drastic measures and incur the danger of producing a scar more disfiguring than the original lesion Greater precision in refrigeration is obtainable with the cryocautery

(2) *Chemical Destruction by Trichloracetic Acid* Trichloracetic acid, owing to its dehydrating effect on the tissues, acts as a caustic, and is often effective in the destruction of capillary angiomata The crystals are liquified with a drop of water, and the solution is applied to the tumor on a glass rod, care being taken that no liquid runs over the healthy skin The area is then covered with a neutralizing ointment of sodium bicarbonate. In time the growth shrinks, and a firm crust forms which falls off spontaneously The treatment may be repeated if necessary

(3) *Electrocautery* Elevated capillary angiomata may be sliced off with an endotherm knife (undampened oscillations of the high frequency current), but this method has the disadvantage of leaving an unsightly scar.

Electrodesiccation (Monopolar High-Frequency Current of the Oudin Type). Elec-

trodesiccation is a simple, rapid, and economical procedure capable of destroying all types of small angiomata. It possesses the disadvantage, however, of leaving an ugly white scar. Previous to the desiccation the area around the angioma is compressed with a metal ring. With a sewing needle electrode a small spark is applied to the center of the lesion and carried in a concentric manner toward the periphery.

Ultraviolet Irradiation. Ultraviolet irradiation is often effectual in the obliteration of capillary angiomata. It is administered in doses sufficient to produce erythema and vesiculation. Ten minutes' exposure from a water-cooled lamp placed at a distance of ½ inch from the skin is usually all that is required. A dermatitis results, which is treated in the usual manner. If necessary, the treatment may be repeated in 3 or 4 weeks.

Mechanical Pressure. In the case of well-limited angiomata occurring in children under 3 months of age, *Matas* (78) advocates the use of pressure. A rubber sponge 1 to 2 cm. in thickness and somewhat larger than the lesion is placed over the growth and kept under constant pressure by means of adhesive strips.

Congenital Non Vascular Growths

In the group of congenital non-vascular growths is included a variety of circumscribed pigmented lesions in which the epidermal and connective tissue elements, rather than the blood vessels, are responsible for the condition. Although these tumors are thought to be congenital, they may not become apparent until some time after birth. Histologically, they are characterized by a hypertrophy of one or more of the elements comprising the skin, and the predominance of one element over the other determines the type of lesion. They all show characteristic nests of large round or oval cells containing deeply staining nuclei, vacuoles, and pigmented granules called "nevus cells." The pigmentation is ascribed to a migration of the melanoblasts, or melanin forming cells, from their normal location in the basal layer of the epidermis into the corium where they continue to produce melanin.

These developmental anomalies are subject to wide variations in number, size, distribution, color, and consistency. They may be single or multiple and they range in size from a pinhead to an area covering an entire part. In color they vary from pale yellow to dark brown or black. Some are hard and flat while others are soft and pedunculated. Their surface is either smooth or warty and the skin covering may be thickened or atrophied, hirsute or hairless. They may occur upon any part of the body, but the most common site is the face, where they are frequently distributed along the course of cutaneous nerves or embryonic lines of union.

While any combination of the above characteristics is possible, the forms most frequently encountered are the following. (1) *Non Hairy Pigmented Mole.* The simplest form of non-hairy pigmented mole is the *nevus spilus* which usually appears as a small non-elevated, hairless, pigmented spot, light to dark brown in color, and ranging in size from a pinhead to a pear or occasionally larger. These lesions are often widely disseminated over the body. Aside from the increased amount of pigment there are but few changes in the skin structure. Another variety which presents similar characteristics is the *blue* or *blue-black mole,* which may be slightly elevated or depressed below the surface of the skin and is said to be potentially malignant. (2) *Hairy Mole* (*Nevus Pilosus*). This type ranges in size from a pin point to an area so large as to

involve the entire face The amount of pigment varies, but as a rule these growths are light yellow to dark brown (3) *Fibromatous Mole* (*White Mole*) This variety of mole appears as a soft waxy growth sparsely pigmented, usually hairless, and containing fat and nevus cells They are difficult to differentiate from fibromata (4) *Warty Mole* (*Nevus Verrucosus*) These moles are principally epithelial in origin, vary in color from pinkish to violaceous or dark brown, are elevated above the skin, and have a tendency to arrange themselves in bands or patches on the side of the face Their surface is mammillated, owing to hypertrophy of the papillae

Moles grow slowly to a given size and then, as a rule, remain stationary They rarely become malignant If the ordinary mole undergoes such a change, however, the malignant process is usually superficial and shows little tendency to spread It is generally admitted that the danger of malignant degeneration is greater in the smooth, shiny, hairless, black or blue-black variety A predisposing factor, as in the case of all malignancies, is irritation The possibility that moles may become malignant, however, must necessarily be slight, when one compares their great frequency with the rarity of melanotic sarcoma and carcinoma Therefore, except for cosmetic reasons, they are best left alone, unless located in areas where they are subject to continuous irritation, such as (1) contiguous surfaces of the skin, (2) parts of the neck where the clothes cause friction, or (3) on the face along the lines of contact of the eyeglasses They should also be kept under observation if they have been subjected to chemical treatment in an attempt at their removal Should they tend to become enlarged or thickened, increase in vascularity, deepen in color, or develop a proneness to bleeding or ulceration—especially if there is an associated enlargement of contiguous glands—or should the urine show melanin pigment, they must be widely and completely removed and the tissue examined microscopically for evidence of malignancy In these cases the cosmetic result becomes subservient to the necessity for complete eradication of the growth Dawson (28) states "If the extirpation is not sufficiently wide, not only has pathologic tissue been left in situ, but also more harm than good may have been done by opening channels of metastasis into subepidermal layers or into the lymphatic nodes of adjacent regions "

Management

Each lesion presents an individual problem, and the choice of treatment will depend upon the age of the patient, the likelihood of malignancy, the location of the growth, and the importance attached to the subsequent scar Small growths offer no difficulty, as they can usually be excised and the skin approximated directly after their removal (p 69) They may likewise be eradicated by electrodesiccation or electrocoagulation and the destroyed tissue shaved down with a fine knife to the level of the skin

Hairy moles appearing on exposed surfaces can be rendered less conspicuous by the removal of the hair with an epilating wax The formula advocated by Pusey (97, 123), consisting of beeswax 1 part by weight and finely powdered rosin 4 parts by weight, is simple and easy of application "To apply, heat one of the cakes on the end of a stick over a flame until soft When cooled to a bearable temperature, rub it on the hair to be removed, rubbing in the direction of the hair, until the wax is about an eighth of an inch thick, pressing it down well on the hair When cool, loosen the end next the ends of the hair and pull off the whole mass in the direction opposite to the growth of hair " A more satisfactory result can be obtained by destroying the hair

follicles with the negative pole of a galvanic current. Cipollaro (16) employs the following technic "The area to be treated is first washed with soap and water, and cleansed with benzine or carbon tetrachloride to remove all fatty substances. It is then dried with sterile gauze and 70 per cent alcohol by weight is applied The operator's hands are thoroughly scrubbed with soap and water and rinsed with alcohol. The needle is sterilized by immersion for ten minutes in alcohol and is attached to the negative terminal. The needle holder must be clean and a surgically clean towel is put over the patient's eyes in order to protect them from the light and also for the deposition of removed hairs. The patient holds a wet sponge attached to the positive terminal in the palm of her hand. The operator is now ready to insert the needle into the follicle. That portion of the hair projecting above the surface of the skin is used as a guide for the needle. By delicate manipulation, the direction and the depth of the follicle are easily and quickly found. While the needle is held in place with the right hand, approximately 0 5 milliampere of current is allowed to act on the hair follicle. As a rule not more than one minute of time nor more than one milliampere of current is essential for this operation Every few seconds the hair which is being treated is grasped by the forceps, which is held in the left hand, and a slight tug is given to the hair If the hair has been thoroughly acted on by the galvanic current it will slide out of the follicle easily The needle is then withdrawn. This process is repeated on the next hair Contiguous hairs should not be removed, because the current is apt to set up a mild inflammatory condition of the skin preventing healing As a rule not more than three or four hairs are removed from a dime sized (18 mm in diameter) area of skin Dimpling of the skin, resistance to the entrance of the needle, edema, delayed appearance of the foam on the surface, excessive pain and muscular contraction indicate improper insertion of the needle The usual length of each treatment is approximately thirty minutes and the interval between treatments is approximately one week After the treatment the skin is swabbed with alcohol and dried, and calamine lotion with 1 per cent phenol is applied.

The blue-black variety of moles because of their potential malignancy, are either left alone and kept under close observation, or are completely excised in a one-stage operation, the incision being carried well into the healthy area without consideration of the cosmetic results. In the removal of these growths any treatment which entails a successive series of surgical procedures or irritative therapy should be eschewed, since such management may lead to malignant changes.

In the case of more extensive lesions, where direct closure following removal is impossible the problem is more difficult. Such growths are best extirpated in toto and the wound covered with a skin graft. Should hypertrophic scars form at the margins, they may be thinned down by Roentgen irradiation Other forms of therapy such as radium, cauterization electrolysis and carbon dioxid snow refrigeration, are on the whole unsatisfactory

Acquired Vascular Growths

Angioma Araneum (Spider Nevus)

Angiomata aranea, unlike other types of angiomata, first make their appearance in adult life. They occur as single or multiple raised spots 1 to 2 mm. in diameter, surrounded by an areola of tortuous spiderlike blood vessels, and usually affect the face in the vicinity of the nose These lesions can be destroyed by electrolysis with a

monopolar current, the same technic being employed as in the treatment of hypertrichosis (p 1321) The electric needle is inserted into the central artery and allowed to remain in place for 10 to 30 seconds It is then gradually withdrawn, the current being left unbroken, in order that the opening may be sealed and hemorrhage prevented Complete eradication of the lesion usually requires several such treatments

Cirsoid Aneurysm (Plexiform Angioma, Racemose Angioma, Aneurysm by Anastomosis)

Cirsoid aneurysm is a type of angioma formed by a direct arteriovenous communication, the blood passing from the artery to the vein without the intervention of a capillary bed The first description of the clinical features and the morbid anatomy of this condition was made by Hunter (57) in 1757 In 1833 Breschet (12) coined the term "cirsoid aneurysm," and Virchow (118) later referred to the lesion as "angioma racemosum arteriale " Craig and Horton (21) state "There is still a tremendous amount of confusion in both the literature and textbooks regarding this type of lesion, and this has resulted from the fact that various writers on the subject have failed to realize that abnormal arteriovenous communications can give rise to such a variety of clinical pictures Hence, they describe the various superficial manifestations of a fundamental pathologic process with the idea that they are describing different diseases If the writer himself is so confused, surely the reader must be even more so In the literature, for example, appear the terms 'cirsoid aneurysm,' 'arteriovenous aneurysm,' 'pulsating venous aneurysm,' 'arteriovenous varix,' 'aneurysma serpentina,' 'angioma plexiforme,' 'angioma arteriale,' 'angioma arteriale serpentinum,' and 'angioma arteriale racemosum ' In reality these terms are merely descriptive of superficial manifestations of a single underlying condition, arteriovenous fistula The fundamental condition is the same and the resulting processes in the vascular system are similar whether the arteriovenous fistula is in the foot or in the cranial cavity "

These lesions are initiated by trauma applied to malformed vessels They are encountered most frequently in men between the ages of 20 and 30 Only rarely are they present at birth, and even in these instances they have been attributed to injury received during delivery Lewis (67) in 1930, after a survey of the literature, reported but 30 congenital cases The exact pathogenesis of these growths, like that of other forms of angioma, is not quite clear, but the most acceptable hypothesis in explanation of the presence of the anastomotic channels between otherwise normally developed arterial and venous trunks is that the embryonic communications existing in the primary anlage fail to become obliterated Because of the low resistance at the site of the arteriovenous communication as compared with that in the peripheral capillaries, the blood in the affected artery is diverted from its usual course and flows through the fistulous opening directly into the vein Since the capillary bed which ordinarily equalizes the pressure between the artery and vein is absent, the blood enters the vein under arterial pressure, and the vein with its thin wall being incapable of withstanding the force, undergoes dilatation Such fistulae are usually multiple, except in traumatic cases in which the blood vessels are not primarily defective In these instances the anastomosis is single (83)

Cirsoid aneurysms occur most frequently in the auriculotemporal region The severity of the symptoms depends upon the caliber of the blood vessels involved, the size of the fistula, and the duration of the lesion The patient complains of headache,

and sensations of buzzing, whirring and throbbing over the affected area, which may be so disturbing as to interfere with sleep Objectively, the lesion on inspection appears as a convoluted, pulsating tumor elevated above the surface and containing tortuous, enlarged vessels running in all directions from a central angiomatous mass. The skin over the affected area is bluish in color and is frequently the seat of an over lying nevus. These aneurysms vary in size and sometimes attain such proportions as to involve the entire scalp Palpation over the affected area reveals an increase in surface temperature, pulsations, and, in the case of large tumors, a distinct thrill. By pressing on the afferent vessel it is often possible to effect a disappearance of the growth. On auscultation a distinct bruit is audible, unless the fistula is small. Efforts to explain the sound have led to much discussion. Billroth believed it to be due to the impact between the arterial and the venous blood, Franz, on experimental evidence, claims that it is caused by a vibration of the wall of the vein at the point of anastomosis and is related to the well known "venous hum", others assume that it is the result of a change of flow in the blood mass as it passes from a narrow tube into a larger space (43) X ray examination in long-standing cases sometimes reveals an erosion of the skull. Tests of the blood withdrawn from the normal and the affected sides, according to the methods of Peters and Van Slyke (94), show a quantitative difference in oxygen saturation. The lesion mav also be demonstrated by arteriography after the injec tion of colloidal thorium dioxid into the vascular tree

Treatment. Cirsoid aneurysms, aside from the subjective symptoms they occasion may give rise to formidable hemorrhage due to atrophy and ulceration of the overlying skin, or they may spread to the intracranial vessels by eroding the bones of the skull.

Excision is the only dependable method of eradication. While this is frequently associated with alarming hemorrhage, nevertheless it must be resorted to, since less drastic measures, such as continued pressure, ligation of the afferent vessel, radiotherapy, electrocoagulation, injection of sclerosing solutions, and electrolysis, are in evitably followed by a recurrence of the lesion

Before any attempt is made to extirpate the aneurysm, preliminary steps must be taken for the control of hemorrhage As in other forms of angioma, the patient's blood should be matched and a donor kept in readiness. The usual local measures for the control of bleeding from the scalp, as described on page 549, are adopted. If the growth is extensive, it is advisable to effect a temporary obstruction of the external carotid artery by placing a provisional ligature around it.

Unfortunately, however, because of the free collateral circulation of the head, hemor rhage is apt to be profuse and even alarming, in spite of every provision taken against it. Probably the best means of preventing serious hemorrhage is to carry out the operation in 2 stages, 3 or 4 days apart In the first stage a flap containing the angiomatous mass is merely separated from the skull, and in the second the mass is excised from the under surface of the flap and the latter replaced and sutured.

First Stage (fig 887-a, b) Under local or endotracheal anesthesia a horseshoe-shaped flap, with its pedicle below, is outlined by means of an incision carried down to the subaponeurotic layer in the healthy tissue at a considerable distance from the central pulsating angiomatous mass. Hemorrhage is controlled by drawing the aponeurosis over the bleeding vessels with multiple hemostats. The flap is then carefully dissected up as far as the angioma, and all dilated and tortuous vessels are isolated,

doubly ligated, and divided as they are encountered At the margin of the growth the knife is directed further downward, in an attempt to reach a plane well beneath the tumor The dissection is continued in this deeper plane, centimeter by centimeter, until the lower limits of the growth are passed, hemorrhage being controlled by compression of the flap against the bone After the separation has been completed, the pedicle of the flap is loosely compressed with an intestinal clamp Finally, a moist gauze pack is laid over the wound, the flap is replaced over it but not sutured, and a dressing is applied

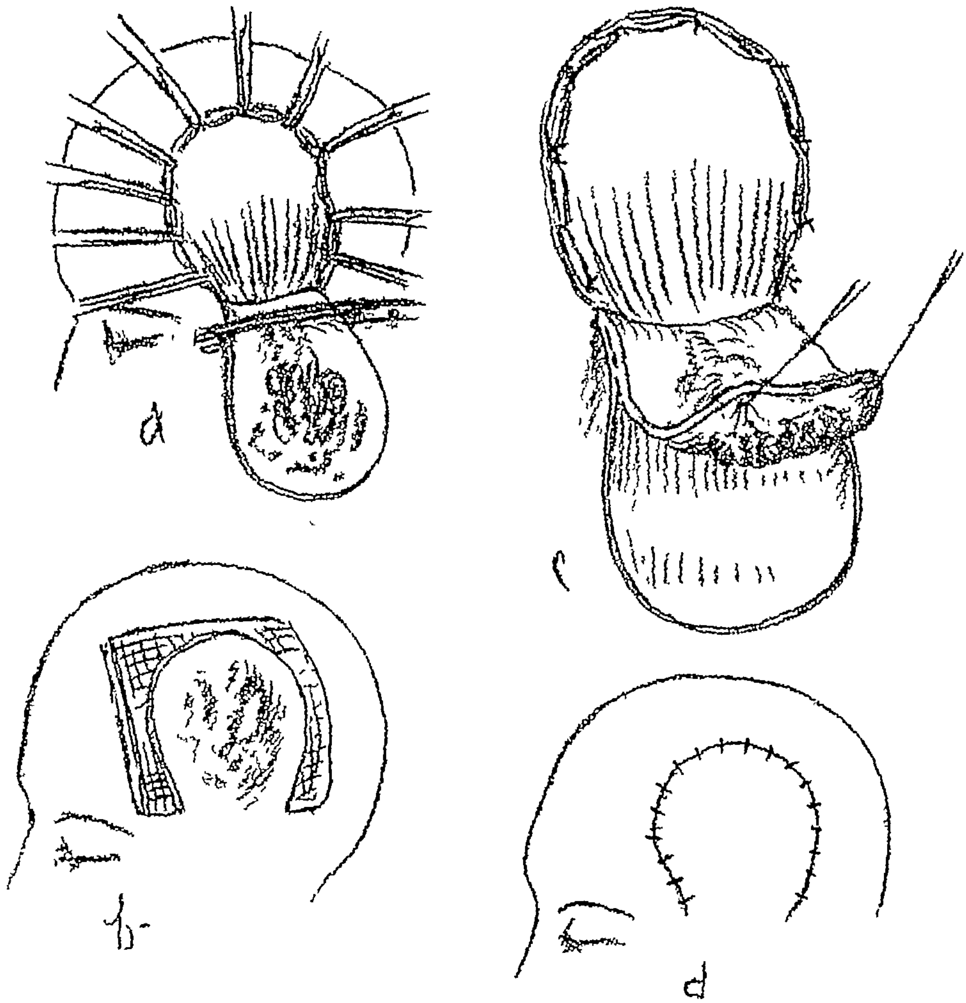


FIG 887 Removal of cirsoid aneurysm *a,* horseshoe-shaped scalp flap, containing angiomatous mass, turned down Hemorrhage controlled by drawing aponeurosis over bleeding vessels and clamping pedicle of flap *b,* flap replaced over wet saline dressing for 3 to 4 days *c,* at second stage, flap turned down Thrombosed tissue stripped from skin and removed *d,* scalp flap replaced For details, see text (Clunie)

Second Stage (fig 887-c, d) Three or 4 days later, when thrombosis will have taken place in the angioma, the scalp flap is again turned down If the skin is not too much involved, the angiomatous mass is stripped from it, what remains of the afferent vessel is ligated; and the flap is sutured back in place In case of extensive oozing, drainage is instituted If the skin of the flap is so degenerated that it cannot be used as a cover, it is excised together with the growth, and the remaining raw area is covered with contiguous sliding flaps or with a skin graft To avoid recurrence, every part of the

growth must be removed, and since the communicating channels are often indefinable, some difficulty may be encountered. The evidence of complete eradication is a disappearance of the bruit, and this can be ascertained by auscultation with a sterilized stethoscope placed over the affected area. During this procedure the blood pressure should be checked, since a decreased pressure may in itself cause a disappearance of the sound (36)

DERMOID CYSTS (CONGENITAL DERMOIDS, SEQUESTRATION CYSTS INCLUSION DERMOIDS)

Dermoid cysts are of congenital origin and have been attributed to an abnormal infolding of the fetal skin structures during the closure of an embryonic fissure, such as the mid-dorsal, midventral, or branchial cleft (19) They may be present at birth, or may not appear until several years later According to New and Erich (85), about 60 per cent of these growths develop between the ages of 15 and 35 Their incidence in the region of the head is comparatively rare. Among 1,495 cases of dermoid cysts observed at the Mayo Clinic between 1910 and 1935 only 6 9 per cent occurred on the head and neck. These cysts are unilocular Their walls are thick and fibrous and are lined with a skinlike membrane composed of squamous epithelium, hair follicles, and sweat and sebaceous glands the layers being in the reverse of the normal order—i e., the horny layer is innermost. The cavity is filled with caseous material consisting of degenerated epithelial cells and sebum mixed with hair Not infrequently, the cyst opens externally through a sinus from which sebaceous material can be expressed. Congenital dermoids of the teratoma type, containing elements of all the germinal layers, are exceedingly rare in the region of the head.

As dermoid cysts form at lines of fusion, they are most frequently encountered about the angles of the orbit and in the region of the auricle, the anterior fontanel, the occipital protuberance, and the floor of the mouth. They appear as smooth, rounded, painless swellings ranging in size from 1 to 2 cm. or more, and may be soft and doughy or elastic and fluctuant They lie free in the deep tissues, their only point of attachment being at their bases, from which cordlike extensions may branch off to surrounding structures The skin above, unlike that which covers sebaceous cysts, is freely movable. These growths give rise to no symptoms, except when they are traumatized or develop into discharging sinuses.

New and Erich (85) classify dermoid cysts of the head into four groups according to their situation and embryonic structure (1) Cysts about the orbit, originating in the naso-optic groove. These are especially frequent (49.5 per cent) and are derived from epidermal inclusions of small groups of cells which dip into the deeper tissues and become separated from the surface epithelium in the fusion of the maxillary and mandibular processes. They occur most commonly on the outer third of the supra orbital ridge and may extend into contiguous regions. (2) Those about the nose, resulting from inclusion of the frontonasal plate between the embryonic nasal dermis and mucosa. These begin as a small nodule which in time forms a sinus. They cause no discomfort, unless they become infected. Their pathogenesis in this location is explained by Luongo (71) as follows 'In the early embryo the frontonasal plate which forms the nose, consists of a lamina of hyaline cartilage covered externally with skin and internally with mucosa. After the third month of embryonic life, bony tissue

extends in between the cartilage and skin The bony tissue will form the nasal bones The cartilage becomes absorbed during the process of ossification During the gradual separation of the skin from the cartilage of the frontonasal plate by the intrusion of the nasal bones, small portions of the skin or epithelium become sequestrated and develop into dermoid cysts" (3) Those about the floor of the mouth and in the submental and submaxillary regions, originating from the upper branchial clefts (23 3 per cent) A cyst occurring in the floor of the mouth may displace the tongue upward or bulge into the submental region, forcing the mylohyoid muscle in front of it A submental or submaxillary cyst may force the muscle into the oral cavity and occasionally perforates it Cysts in this locality interfere with speech and mastication

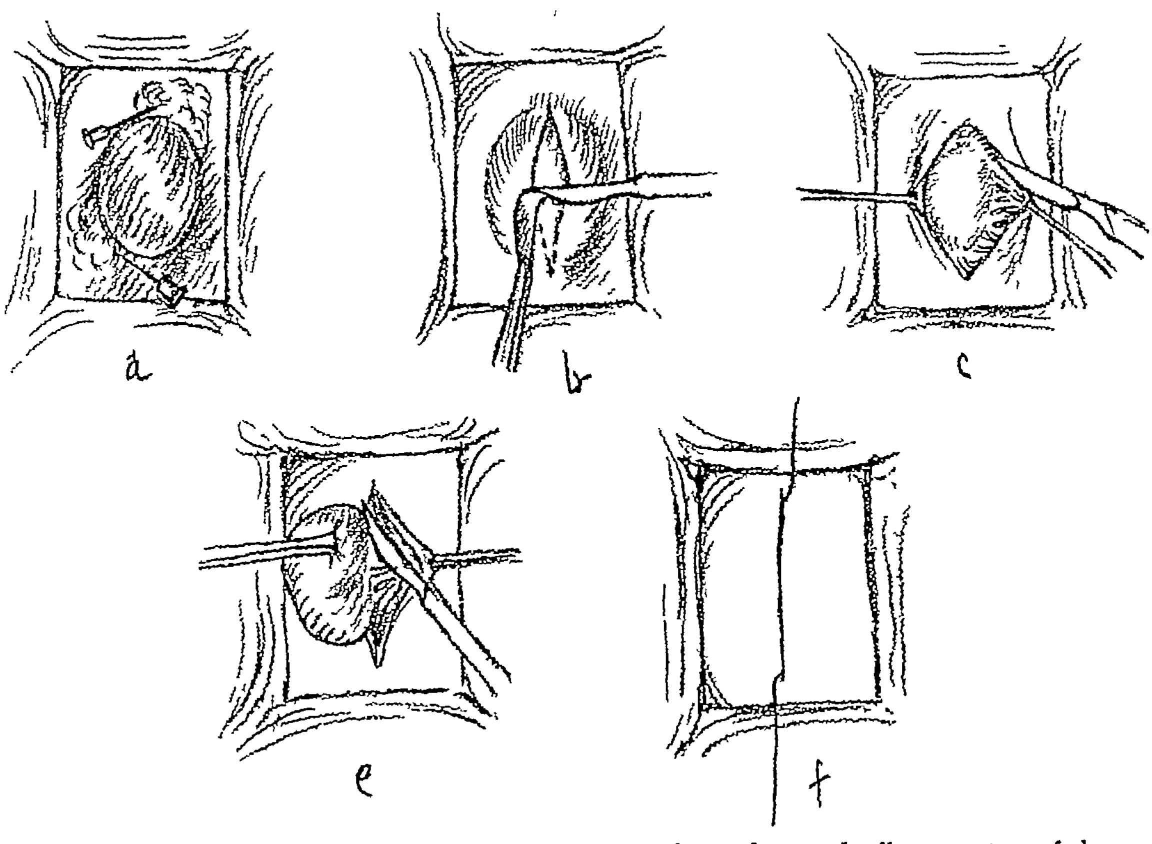


FIG 888 Removal of dermoid cyst *a*, circumferential anesthesia *b*, elliptic section of skin, including sinus, excised *c*, cyst freed along line of cleavage *e*, prolongations of cyst excised *f*, skin closed with subcuticular suture

They must be differentiated from cystic hygromata, cysts of the thyroglossal duct, branchial cysts, lipomata, and gland infections (4) A group of cysts which occur in the midline, developing during closure at the midventral and mid-dorsal lines of the body (14 6 per cent) These are found in the occipital, frontal, and lower lip regions

In rare instances cysts of the head may be acquired and in such cases are of the epidermoid implantation type They follow the forcible implantation of a separated fragment of epidermis into the subcutaneous tissues (107)

Treatment. Dermoid cysts demand removal because of their mechanical interference with function, the deformity they occasion, and their tendency to undergo infection They are not likely to recur if the entire cyst wall has been removed X-ray examination is essential before excision, to determine the limits of the growth If the

cyst is attached superficially, its removal is a simple matter, and the technic is similar to that employed in the enucleation of a sebaceous cyst (fig 888) But when the growth is deeply embedded, when it is attached to bone or has many cordlike extensions, its excision may entail considerable difficulty In the event of a communication with the cranial cavity, removal should not be undertaken until after puberty, since there is a possibility that the growth of the skull bones may shut off the opening

The technic for the removal of a dermoid cyst is as follows A linear incision is made over the cyst along the lines of skin tension. When an external sinus is present, the incision is made in the form of an ellipse to include the sinus, and the elliptic section of skin is removed with the growth Tumors in the vicinity of the orbit are exposed through an incision concealed in the eyebrow, those in the mouth above the mylohyoid muscle are approached through an intrabuccal incision, those below the mylohyoid are more conveniently reached through a transverse incision parallel to the lower border of the mandible. The separation of the overlying skin will offer no difficulty After the skin incision has been made a line of cleavage is established and the cyst is freed by blunt dissection It is then opened and emptied, so that the extent of the cavity may be ascertained.

As has been said before, the entire cyst wall must be removed as a guarantee against recurrence of the growth If it is found to be attached to the periosteum, the latter is excised with it. In cases where prolongations of the sac reach down into the nasal septum, so that complete removal would create too great a deformity, or when the growth extends through the skull into the pachymeninx, as much of the sac as possible is excised and the remainder destroyed by cauterization The wound is then closed in the usual manner and a pressure dressing applied.

Sebaceous Cysts

Sebaceous cysts have a predilection for the scalp and face and are due either to congenital absence of the excretory duct of the gland, or to its obstruction following inflammation or inspissation of the secretions. As a result the glandular products accumulate and the walls become distended and thickened, the overlying skin is stretched, the follicles atrophy, and the hair falls out. On section the cysts are found to be filled with a cheesy or fluid mass composed of sebum, degenerated epithelium, and cholesterin crystals. Unless inflamed these growths appear as rounded sharply defined, elastic semisolid swellings, firmly embedded in the skin but freely movable on the underlying structures They are usually single but may be multiple They range in size from a split pea to an egg or larger The duct may remain partly patulous, permitting of the expulsion of the contents of the gland, but more frequently it is entirely obliterated, its outlet appearing as a black speck at the apex of the mass. The tumors are painless and of slow growth and after reaching a certain size they remain stationary for years. Because of their exposed location, they are subject to inflammation and infection.

Treatment. The skin is prepared as for any operation, and if the cyst is situated in the scalp, the hair is shaved 1 inch beyond the margin of the growth The operation is performed under local anesthesia, the infiltration being made in the plane between the tumor and the surrounding tissues. The base of the cyst is transfixed with a narrow scalpel which is brought to the surface and thus made to bisect the mass.

The contents are then expressed, and each side of the sac is grasped with a hemostat and twisted out

If the cyst has been inflamed, it will be best to dissect it out intact, as follows (fig 889) · If the overlying skin is normal, it is incised over the most prominent part of the mass in the direction of natural tension lines, care being taken to avoid penetration of the sac, but should it be atrophied, it is incised in the form of an ellipse and sacrificed A dull elevator is then inserted into the cleavage plane between the cyst wall and the surrounding tissues and is swept around the sac, separating it from its bed Special care must be taken during this procedure to avoid perforation of the sac Should such an accident occur, the caseous material is wiped away and the cyst wall grasped with a mosquito forceps and twisted out Any small portion of the sac left behind should be

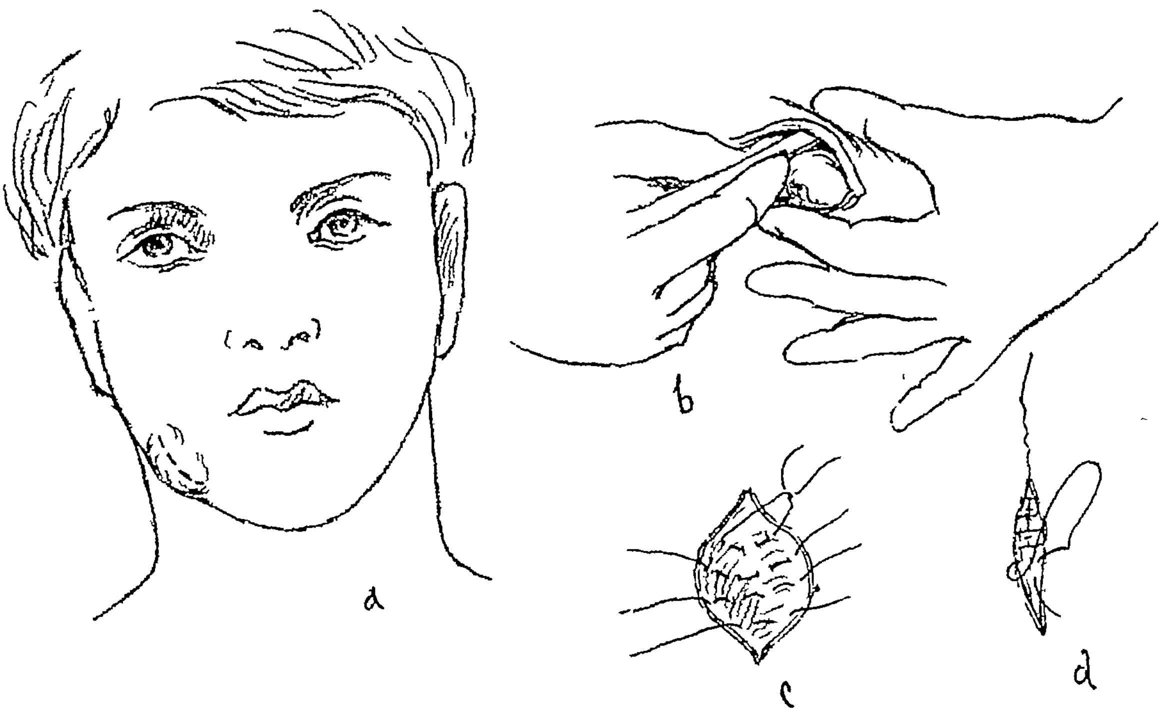


FIG 889 Removal of sebaceous cyst. *a*, line of incision. *b*, cyst wall separated along cleavage plane *c*, subcutaneous sutures passed, to obliterate dead space *d*, wound closed with subcuticular suture

scraped away with a curet or destroyed with a cautery, otherwise, the growth will be likely to recur The skin is then coapted by means of interrupted on-end horsehair sutures or an intradermal silk suture Finally, a pressure bandage is applied for the obliteration of any possible dead spaces in the wound

FIBROMA

Fibromata occur as circumscribed, elevated tumors which may be soft or dense, sessile or pedunculated, and range in size from a pinhead to an orange or larger. They appear early in life and are more commonly found in the male and in individuals of the darker races They grow slowly to a given size and then become stationary They occasion no subjective symptoms Histologically, they are characterized by a hyperplasia of the connective tissue of the corium, of the nerve sheaths, or of the subcu-

taneous tissue The soft variety is vascular and consists of interlacing strands of loose areolar tissue containing many spindle-shaped cells. The dense form is more compact and less vascular, and when cut shows a glistening surface. In either type the over lying skin may be normal, hypertrophied, or pigmented, and is usually hairless. The growths may be multiple (fibroma molluscum seen in multiple neurofibromatosis or Recklinghausen's disease) occurring as many projecting tumors, some of which form enormous masses which cause grotesque disfigurement and mechanical inconvenience Von Recklinghausen has demonstrated that the majority of these multiple growths are neurofibromatous in origin.

Treatment. When these growths are disfiguring or cause mechanical disturbance of function, they should be excised They shell out easily from the surrounding tissue, except at the point of fixation, and do not tend to recur In the case of multiple neurofibromatosis it would obviously be impracticable to excise all the tumors, and in such instances the removal is limited to those which occasion the greatest inter ference with function

Paraffinoma

A paraffinoma is a benign tumor developing as a result of the hypodermic introduc tion of paraffin or some other hydrocarbon. The use of paraffin for prosthetic purposes was introduced by Gersuny (47) of Vienna in 1899, who according to Ormsby, "first injected a quantity of paraffin, having a melting point of 40 degrees C., into the scrotum to replace lost testicles, for the purpose of hiding the deformity in a candidate who contemplated taking the physical examination for entrance into the army service." The procedure was later advocated by Corning Eckstein, and others for the filling out of various facial defects, and it soon gained wide popularity because of its simplicity of application and its immediately satisfactory results. Paraffin came to be used for the building up of the saddle-nose deformity, the "smoothing out" of wrinkles, the formation of dimples, and for changing the contour of the face. But as the disastrous consequences of the practice gradually became recognized, the method was discredited and has now been entirely abandoned Patients still occasionally present themselves. however, giving a history of paraffin injections for cosmetic reasons.

Following the subcutaneous injection of paraffin symptoms do not appear for several months to years Then without apparent cause the mass becomes active, infiltrates the skin, takes on the character of an infected foreign body and gravitates from its site of introduction to some dependent part of the face notably the regions between and beneath the eyes along the ala nasi and the angles of the mouth, beneath the chin, or on the neck. The tumor appears as an irregular lumpy oval mass of firm consistency and varies in color from yellow to bluish red and in size from a pea to an egg or larger The *overlying skin is stretched and glossy, covered with dilated blood vessels, and is* adherent to the growth. The lesion advances to a certain point and then may undergo a complete fibrosis which, according to Heidingsfeld (53) is its natural goal. The tendency of these growths to become malignant is slight. Davis (26), however, reports a case which developed into a carcinoma, and Wise vouches for one which resulted in sarcoma. Frequently they break down as a consequence of infection or necrosis or show evidences of a chronic progressive inflammation. There are no subjective symptoms, aside from the discomfort arising from pressure.

Pathologically, a paraffinoma is essentially a connective tissue growth of a granulomatous nature and resembles an early tuberculous lesion It is composed of fibrous connective tissue showing evidences of a foreign body reaction, as manifested by giant-cells, endothelial cells, plasma cells, and fibroblasts Heidingsfeld (52, 53) calls attention to a series of many cavities which give the area an appearance not unlike that of a piece of Swiss cheese, the spaces corresponding to the localities formerly occupied by the paraffin The affected part is incompletely encapsuled in a wall of fibroconnective tissue

The only effectual *treatment* of paraffinomata is excision, and this entails considerable difficulty and often falls short of a satisfactory result, inasmuch as the particles of paraffin are intimately bound up with the newly formed connective tissue, and the overlying skin is in such a poor state of nutrition that necrosis and ulceration are likely to follow An incision following the natural tension lines is made in the skin directly over the growth, and the small masses are picked out with a curet Frequently, this can be effected only by the excision of portions of the connective tissue containing the granules, and in cases where there has been extensive infiltration the whole area including the overlying skin must be removed and the remaining deformity corrected by a series of plastic operations

Lipoma

Lipomata are the most common type of tumors found in the face and are most frequently encountered in the region of the forehead They may be rounded or lobulated, are as a rule localized and sessile, and vary greatly in size, sometimes forming masses which weigh several pounds They are the only form of benign tumors which never become malignant Finch (41) states "The only rational tumour is the lipoma, it will never disgrace its innocence, however old and big it may be" They are enclosed in a fibrous capsule loosely connected with the surrounding structures, but when subjected to irritation or infection they may become firmly adherent On palpation they are soft and semifluctuant, and when displaced they slip beneath the fingers, the overlying skin dimpling at the points of attachment

Aside from the localized variety of lipomata, there are other forms common to the skin, such as diffuse lipoma and the type which characterizes adiposis dolorosa, or Dercum's disease A diffuse lipoma is not encapsuled, contains more fibrous tissue than the localized form, and is usually bilateral Its most common site is beneath the chin and on the back of the neck These masses differ from normal accumulations of fat by their irregular outline and asymmetrical distribution The condition known as adiposis dolorosa is thought to have some relation to a dysfunction of the thyroid gland. It is observed most commonly in women about the climacteric and is evidenced by the accumulation in various parts of the body of masses of fat resembling diffuse lipomata and is accompanied by severe pain of a neuralgic type

Although lipomata are for the most part innocent painless growths, their removal is sometimes indicated for the relief of deformity or mechanical interference with function, and is occasionally imperative because of degenerative and infective changes occurring within the tumor

Treatment. Growths of the localized type can be readily enucleated, as they are relatively free within the tissues An incision is made in the overlying skin parallel

to the tension lines and deepened until the capsule becomes visible. Should the growth be in the vicinity of the facial nerve, injury to its branches can be avoided if the incision is made parallel with the course of the nerve. Fortunately, however, the tumor in its development usually forces the nerve fibers to one side, so that there is little danger of such an accident. After the capsule has been exposed, the tumor is separated from the surrounding tissues by blunt dissection following lines of cleavage, and the mass removed intact (fig 890) Hemorrhage is controlled by ligation. Should the tumor be in the vicinity of the facial nerve, the capsule is opened and the fat enucleated, and since there is no tendency on the part of these growths to recur, the capsule may be allowed to remain. In either case the cavity is obliterated by the turning in of

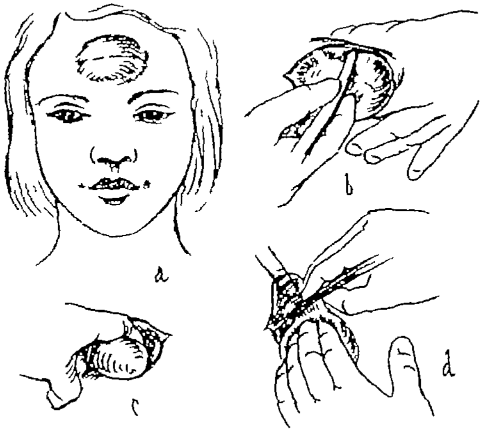


FIG. 890. Removal of lipoma. *a* line of incision. *b*, tumor bluntly separated from surrounding tissue along line of cleavage. *c* separation continued with finger *d*, base of growth freed.

contiguous fat flaps, and the margins of the skin wound are closed either with on-end sutures of horsehair or a subcuticular suture of silk. The wound is covered with an elastic pressure dressing Alternate sutures are removed on the second day and the remainder on the third and fourth days.

If the skin overlying the tumor is not serviceable, owing to previous infection or ulceration it is sacrificed with the growth In such cases an oval incision enclosing the tumor is made in the adjacent healthy skin and deepened to a level well below the growth, which is then dissected out together with its capsule. The resultant defect can usually be closed by direct approximation of the wound margins after the deep tissues have been coapted and the skin edges undercut.

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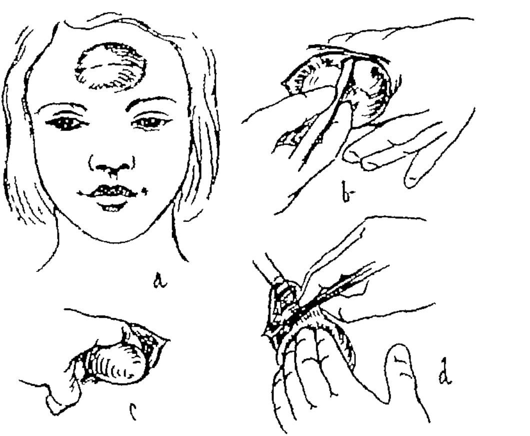

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extensive dissection, owing to the absence of a capsule and the wide dissemination of the fat An attempt should be made to remove the growth intact, but should this be impossible, as is usually the case, an incision is made through the center of the whole thickness of the tumor, and each half is dissected separately from its attachments.

Xanthoma

Of the several varieties of xanthomata the only one of any surgical importance is xanthoma planum, appearing as a shiny soft yellow plate embedded in the corium These growths are roughly rectangular in outline, range in diameter from 3 to 10 mm , and are usually multiple As a rule, they are located in the upper eyelid and run parallel to the margin of the lid Histologically, they show an overgrowth of connective tissue, containing an abundance of lipoid globules which account for their characteristic yellow color They are most common in middle-aged women A hereditary tendency has been noted

Treatment. Because of their striking color, xanthomata are disfiguring and demand removal When the lesion is single, it can easily be removed surgically under local anesthesia. The operative steps are shown in Figure 891 Multiple growths are best

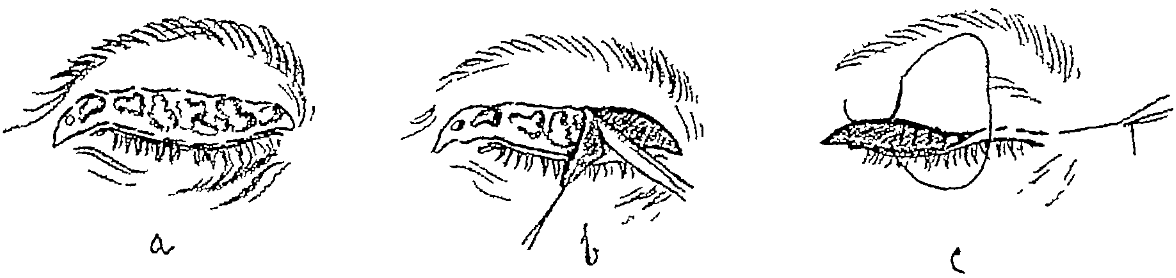


Fig 891 Removal of xanthoma *a*, growth outlined by incision *b*, tumor removed *c*, wound margins approximated with subcuticular suture

destroyed by electrocautery or by the application of caustics, such as trichloracetic acid, or 25 per cent salicylic acid

Papilloma

Under the heading of papillomata are grouped a number of benign neoplasms composed of fat and fibrous tissue covered with epithelium They are, essentially, hyperplastic papillae of the skin, and although their origin is not definitely known, infection is undoubtedly an etiologic factor in their formation. While they may appear at any time of life, they are more common in the aged Their clinical importance lies in the fact that continued irritation may cause them to undergo malignant metaplasia They appear as sessile or pedunculated lesions with smooth or verrucous surfaces Occasionally, the epithelium becomes keratinized and develops hornlike outgrowths Papillomata may be multiple but are more commonly single and range in size from a pinhead to a walnut Their course is variable, and they have a tendency to spontaneous disappearance and recurrence

Treatment The pedunculated form of papilloma may be snipped off with a pair of scissors The sessile variety is outlined by an elliptic incision and excised in the

form of a wedge, the scalpel being directed well beneath the base of the growth, to prevent recurrence and permit of easy closure

They may also be destroyed by electrodesiccation, the entire lesion being dehydrated and then lifted up and cut away with a pair of sharp scissors. The base is then curetted, the edges are trimmed, and the wound dressed. Other forms of treatment advocated for the destruction of these lesions are x ray, radium, the actual cautery, and caustics.

MALIGNANT TUMORS

Carcinoma

Malignant tumors of the skin comprise carcinoma, sarcoma, lymphoblastoma, endothelioma, and metastatic lesions. According to Kees (63), they are responsible for approximately 4000 deaths in the United States each year The only common variety appearing on the face is carcinoma.

The various theories which have been advanced in explanation of the etiology of cutaneous carcinoma have been discussed so often that a review seems superfluous. Therefore, only the contributing factors will be mentioned. Carcinoma of the skin appears most frequently in adult white males giving a history of long continued exposure to the sun's rays, to irradiation therapy, or to contact with certain chemicals, especially tar, paraffin, and arsenic. Such lesions frequently arise at the site of an old burn-scar, a patch of lupus, an area of senile keratosis, a chronic ulcer, or a pigmented nevus. Pusey (97) intimates that a peculiar hereditary quality of the skin, characterized by dryness or dry seborrhea is a predisposing factor

Pathology

As in the case of carcinoma elsewhere, the cutaneous variety is composed of a parenchyma of epithelial cells and a supporting stroma of connective tissue and blood vessels. The characteristic histologic feature of the malignant epithelial *cell* is its power of unlimited multiplication and its proneness to break through the normal limiting basement membrane and invade the subepithelial tissues along the lines of least resistance. Structurally, the cells are anaplastic and tend to revert to an embryonal form Generally, the more they differ from the normal structure and the nearer they approach the embryonal type the more malignant is the growth When the variation is slight, as in basal cell carcinoma, there is a low average of malignancy, but when it is marked, as in the prickle-cell variety, the average is high.

On the basis of the extent of differentiation of these cells from the normal—i.e , their ability to resemble and mimic the normal tissue from which they originate—Broders (13) has grouped the various types of carcinoma into four grades, and while the reliability of such a classification is questionable it has somewhat simplified the diagnosis, prognosis, and treatment. "A carcinoma graded 1 is one in which the proportion of differentiated cells ranges from almost 100 down to 75 per cent, the balance of the cells being undifferentiated In a carcinoma graded 2, the proportion of differentiated cells ranges from 75 down to 50 per cent. In carcinoma graded 3, the proportion of differentiated cells ranges from 50 down to 25 per cent. In carcinoma graded 4, the proportion of differentiated cells is from 25 per cent to practically 0" The growths

resist irradiation in inverse proportion to the degree of anaplasia Tumors of Grades 1 and 2, then, which more nearly mimic the normal structures and are of a lower degree of malignancy, are relatively radioresistant, whereas tumors of Grades 3 and 4, which are more anaplastic and highly malignant, respond readily to such treatment

The appearance of the *stroma* varies with the rapidity of growth In slowly growing tumors it is dense and fibrocicatricial and contains few blood vessels, whereas in those of more rapid growth it is comparatively scanty, more cellular, and more vascular Like all types of carcinoma, skin cancer spreads by local infiltration and by metastasis, principally by way of the lymphatics

Since the type of cancer cell present in the tumor determines to a large extent the clinical behavior of the growth and its treatment, any practical classification of skin cancers must be based on this consideration The various forms of cutaneous carcinoma are as follows.

(1) *Basal Cell Carcinoma* (*Basocellular Carcinoma*, *Rodent Ulcer*), developing in all probability from the deeper or basal layer of the rete mucosum or from analogous cells of the skin appendages It is composed of closely packed interlacing columns of small deeply staining polyhedral or spindle-shaped epithelial cells of various sizes and shapes, with large nuclei and scanty cytoplasm When the tumor arises from the skin appendages, the cells are likely to assume an alveolar arrangement They rarely show keratinization, hence, cell nests are absent

(2) *Squamous Cell Carcinoma* (*Spinocellular Carcinoma*, *Prickle-Cell Cancer*, *Acanthoma*), derived from the outer or prickle-cell layer of the epidermis—whence its name acanthoma, from the Greek, "a thorn" or "a prickle" In its early stages, differentiation from the basal cell type is difficult, but as development proceeds, it can be readily distinguished by the presence of pearl-like epithelial masses composed of groups of concentrically arranged cells which present typical changes The deepest layers show flattened cells with irregular keratinization, the middle strata consist of polygonal cells, and the layers in contact with the stroma contain basal cells differing little from those of normal skin

(3) *Basal Squamous Carcinoma* (*Transitional Carcinoma*, *Intermediate or Mixed Type*), displaying characteristics of both the basal cell and squamous cell varieties Partial pearl formations are often found These neoplasms are radioresistant and tend to infiltrate the tissues, hence, they should be excised more widely and deeply than the basal cell tumors

(4) *Melanotic Carcinoma* (*Nevoid Carcinoma*), characterized by the presence of epithelioid cells, polyheral in shape, with large vesicular nuclei and pale cytoplasm, throughout which are scattered numerous fine or coarse pigment granules The histologic origin of these cells is still a matter of dispute Some believe that they arise from special mesoblastic pigment cells known as chromatophores, but the weight of opinion favors an epithelial origin The appearance of the cells is varied, and areas resembling sarcoma and carcinoma may be encountered within the same tumor Metastasis is widespread and takes place either by way of the blood or the lymph system. The majority of these growths are secondary to pigmented nevi

(5) *Cutaneous Metastatic Growths*, originating in glandular tissue and involving the skin secondarily They may appear as discrete, hard, shotlike subcutaneous nodules freely movable beneath the epidermis, or as large, brawny, sclerodermatous plaques. Their origin can frequently be determined by their histologic characteristics.

Clinical Features

Basal Cell Epithelioma. This variety of cutaneous carcinoma, first described by Jacob, is the type most commonly seen on the face, the chief sites being the inner canthus, the forehead, the pre- and postauricular regions, and the nasolabial folds. It is rarely encountered at mucocutaneous junctions. Occasionally, it begins in a senile verrucous or keratosic area as a thickening of the patch accompanied by slight redness, but more often it starts as a papule ranging in size from a pinhead to a pea, or as a flat topped nodule of a waxy translucent, yellowish or whitish hue, often showing dilated blood vessels on its surface. At first the overlying skin is tightly stretched, giving the growth a shiny appearance. In time it becomes fissured or breaks down to form a shallow indolent ulcer with rolled-over edges. The center is depressed, smooth, and covered with unhealthy granulations. Imperfect attempts at healing result in the formation of smooth atrophic scars which readily bleed and break down. Exudation is absent or slight, unless the ulcer becomes infected, in which case it is profuse and offensive. The border of the ulcer is elevated, of a hard consistency, and a pearly appearance, is covered with telangiectatic vessels, and tends to extend peripherally.

The course of the lesion is slow but continuous. It may require weeks or months to undergo ulceration and several years to reach any significant size. Metastasis to adjacent glands or to distant parts of the body does not occur, as a rule, the growth remains superficial and spreads laterally along the surface, in the manner of lupus. Ewing (38) states that basal cell carcinomata "spread through the dermal lymphatics by proliferation and forming long cords within the lymphatic channels. When the surgeon comes along and decides to do a very radical operation to cut out these tumors he is apt to leave some cells which give rise to recurrence and since these tumors are on the face or around the eye a very radical resection without regard to location would give an unsightly result.' In rare instances the growth penetrates the deeper structures, involving bone, cartilage, or even pachymeninx, but the damage is not as great as that caused by the squamous variety. As the condition is painless and the general health is little affected thereby, it not infrequently happens that patients thus afflicted will defer seeking advice until the disease is well advanced.

Squamous Cell Carcinoma. This type of carcinoma has a predilection for the temple, postauricular region, inner canthus, nose and mucocutaneous junctions. It may begin as a thickening in a keratosic patch or as a small yellowish red, nodular, indurated, scale-covered mass. In either case in the course of a few weeks or months it breaks down to form a deep crateriform ulcer with rolled-over edges. If the constructive process balances the destructive, there results an ulcer with sharply defined edges resembling the rodent type but subject to more extensive induration and infiltration. When the constructive process predominates, it gives rise to a projecting cauliflowerlike mass with a fissured, warty surface covered with an offensive purulent, yellow exudate. Squamous cell carcinoma, unlike the basal type, spreads quite rapidly, involving cartilage, bone, periosteum, and lymph-nodes, and has a tendency to metastasize to distant structures. Pain is not a prominent symptom until late in the disease.

Melanotic Carcinoma. Melanotic cancers are the most malignant of all tumors and usually develop from moles, especially the blue-black variety, only rarely do they originate in hairy moles (p 1320). They have a predilection for the skin of heavily pigmented areas, notably the regions of the external orifices. The growth usually occurs as a single rounded elevation, smooth and shiny, varying in color from slate to

jet black, and ranging in size from a pea to a walnut or larger It spreads with great speed, invading the surrounding skin and subcutaneous tissues, the lymphatic glands, and the blood stream, and in the course of a few weeks metastatic deposits may be found in the viscera Although the most malignant of all tumors, it is not the most rapidly fatal, the average duration of the condition being about three years These growths are resistant to irradiation, and surgical excision offers little hope of cure, because when once they have become clinically manifest, the probability is that they have already reached an advanced stage Nevertheless, if the tumor is still circumscribed, it should be removed as soon as discovered, the excision being made with an endotherm knife carried well beyond the possible limits of the growth, in the hope that metastasis has not yet taken place

Diagnosis

While skin cancer is easily recognized by its location, by the clinical features, and by a history of the duration of the lesion and its rate of growth, a positive diagnosis of the grade of malignancy and an estimation of its radiosensitivity can be ascertained only by a microscopic examination of the suspected tissue Therefore, a specimen for biopsy should be taken routinely before a decision is made to institute any form of treatment (p 447)

Treatment

The aim of treatment is to eradicate the growth completely and at the same time leave a minimum of disfigurement and disturbance in function Obviously, the best results may be expected when treatment is instituted during the early stages of the condition, before deep ulceration and wide extension have supervened It follows, then, that all patients of cancerous age presenting pigmented keratoses, nevi, warty outgrowths, old burn-scars, and patches of radiodermatitis, especially at mucocutaneous junctions and in localities subject to irritation, must be viewed with suspicion and the affected parts carefully watched Should any of these lesions show a tendency to active proliferation, induration, fissuring, or ulceration, the diseased areas should be immediately destroyed

The accepted modalities for eradication are surgical excision, irradiation with radium or x-ray, diathermy, and cauterization, used alone or in combination Absolute certainty as to the method or methods which offer the greatest hope of cure is still lacking The choice will depend upon the available facilities, the type of cells involved, the location of the lesion, the extent of the damage, and the general condition of the individual The best interests of the patient are served when surgeon and radiologist enter into consultation concerning the most appropriate form of treatment

Surgical Excision In view of the inconvenience and expense of irradiation, surgical excision is preferable when the growth is circumscribed and in a location which will permit of complete removal Excision is also indicated for radioresistant tumors The operation can be carried out under local anesthesia, the infiltration being made at some distance from the growth, to avoid the danger of dissemination of the malignant cells On the basis of experimental evidence, which seems to prove that cancer cells cannot be successfully transplanted after they have been heated to 113°F, it is well,

as a precautionary measure, to cauterize the surface of the growth before the initial incision is made and the base after its excision.

The technic for the removal of malignant tumors of the face is the same as that which obtains elsewhere. Briefly, the tumor is circumscribed by an oval incision made in healthy tissue 1 to 1.5 cm. beyond the margin of the growth and extending into the deep fascia. The growth is then removed en masse. Owing to the friability of the tumor tissue, this may occasion some difficulty If the bone is involved, the eroded surface is chiseled away and the base cauterized. If the tumor has invaded the orbital cavity, enucleation of the eyeball may be called for Should the growth be of the squamous variety, the excision must include the adjacent lymphatic glands. Before the wound is closed the excised tissue is frozen and examined, so that a more radical excision may be carried out at once, if necessary, should the margins of the section show cancer cells. Excision with a diathermy knife seals the lymphatics and reduces operative hemorrhage, but this instrument cannot safely be used in the vicinity of important blood vessels and nerves, affords no opportunity for histologic examination of the tissues, permits of less satisfactory healing than that following the use of the scalpel, and is more apt to produce secondary hemorrhage

Following complete removal of the growth and control of hemorrhage, the deep tissues are approximated in layers, the skin margins are undercut and united with interrupted on-end mattress-sutures of horsehair, and a dressing is applied The sutures are removed on the fourth or fifth day depending upon the degree of tension under which the tissues were brought together

If direct approximation of the wound margins is impossible, the procedure to be adopted will be governed by the nature of the tumor In the basal cell type of epithelioma the raw surface may be immediately covered. If the loss is superficial, a skin graft taken from the eyelid or postauricular region is employed, if deep a flap must be resorted to In the squamous type of carcinoma the wound is allowed to heal by granulation, and the patient is kept under observation for several months. When all danger of recurrence has passed, residual scars are excised, and the raw area is covered with a skin graft or a flap Defects of contour are built up by means of bone, cartilage, or fascia grafts introduced subcutaneously The details of the technic are discussed in Chapter II

Irradiation Therapy While it is conceded that irradiation is capable of destroying malignant cells, the mechanism of its action is not clearly understood. In all probability its effects are selective, that is, the malignant cells are more susceptible to the destructive action of irradiation than are the cells of normal tissue. Some investigators believe, however that irradiation acts by blocking the lymphatic channels and thus interferes with the migration of the cancer cells. Still others suggest that it causes a thickening of the capsules of the lymphatic glands and in this way imprisons the cancer cells, without actually destroying them. If the latter theory be true, it may account for the occasional late recurrence of carcinoma following apparent cure by irradiation therapy It also raises the question as to the possible liberation of viable neoplastic cells by the accidental incision of the capsule in surgical operations performed after irradiation therapy has been instituted.

In recent years surgery has been challenged by the success obtained from irradiation therapy, especially since the introduction of the fractional method of irradiation treat

ment advocated by Coutard (20) and Chaoul This method has overcome one of the greatest disadvantages of radiotherapy—namely, that the size of the dose required to destroy the malignant cells is frequently greater than the normal skin can tolerate By the administration of fractional doses at frequent intervals, it is possible to bring about within the tumor cell a cumulative action greater than that exerted on the normal skin This effect is explained on the assumption that the tumor cell requires a longer time to recover from the damage inflicted by irradiation than does normal tissue, and that fractional doses, administered at frequent intervals, and of insufficient intensity to damage the normal skin, will cause a constant bombardment of the multiplying neoplastic cells and thus prevent them from recovering and building up a defensive mechanism

The proponents of irradiation therapy claim that it eradicates the disease without occasioning the hemorrhage and mutilation caused by surgery, that it requires no hospitalization, incurs little loss of time, gives a good cosmetic result with a supple, inconspicuous scar, and when competently managed is free from danger On the other hand, those that prefer surgical excision point out that when there is a recurrence of the growth following irradiation, it is of a particularly intractable type, that secondary treatment by this method is as a rule ineffectual, since the initial irradiation renders the tissue unresponsive, especially when bone has been invaded, and that subsequent surgery is apt to fail, because of the detrimental effect of the initial irradiation treatment on the integrity of the contiguous normal tissue Other possible objections to the employment of irradiation therapy are the long-drawn-out treatment, the associated discomfort, the danger of radiodermatitis, and the toxic reaction from absorption of the destroyed cancer cells. Finally, irradiation is not as readily available as surgery, and the expense in itself is often sufficient to prohibit its use

Irradiation finds its greatest usefulness (1) In extensive growths in the vicinity of the parotid duct or the facial nerve, and around the corners of the mouth and eyes In these localities complete excision would be likely to damage important adjacent structures, and plastic reconstruction is unsatisfactory (2) When the age or general condition of the patient contraindicates surgery (3) In retarding the growth of recurrent lesions following surgical removal (4) In advanced cases as a palliative measure for the relief of pain and to retard the growth of the neoplasm (5) As a postoperative procedure to prevent recurrence (15, 111) Its value in the latter capacity, however, is questionable Fehr (39) states that "since 1930, Regaud, Wintz, and Juengling, have given up irradiation following radical operation for the reason that the irradiation is given in a region in which the presence or absence of disease is unknown The region that must be irradiated is often very extensive If cancer cells are present, their radiosensitivity is unknown Therefore, one is entirely in the dark as to the proper dosage It has been shown that inadequate or excessive dosage may be deleterious. If recurrence appears in the irradiated area, further irradiation treatment promising successful results cannot be carried out The statistics supporting prophylactic radiation can be matched by those of the radium institute for cases in which no after radiation was used"

Irradiation may be administered. (1) In the form of a radium bomb or Roentgen ray, (2) as a surface application in the form of a plaque, and (3) interstitially by means of radium needles which may contain either the radium element or the radium em-

anation (radon) No definite rules can be laid down as to the duration of exposure and the proper dosage The amount in each case must be governed by the cell sensitivity, vascularity, location, and individual tolerance. All radiologists agree, however, that better results are obtained from the administration of small doses frequently repeated than from massive doses given at long intervals. In recent years irradiation with the Roentgen ray has been largely supplanted by radium therapy, because in the former method the dosage cannot be as accurately controlled, there is greater likelihood of recurrence, and, according to some writers, mild forms of malignancy may be converted by x rays into more severe types.

Methods of Application The Suttons (111) advise that "In attacking superficial carcinomata no screen need be used and an exposure of 30 mg hours is usually sufficient to destroy the growth In the majority of instances, the reaction is apparently quite severe, but it disappears in the course of ten days or a fortnight, and the growth generally disappears with it. In the more deeply seated tumors, a 1 or 2 mm. screen should be employed, and much longer exposures given Occasionally better results can be secured by 'cross-firing' applicators being placed on opposite sides of the tumor"

The method adopted by the Radium Institute (100) for the treatment of *rodent ulcer* is as follows "The lesion is measured and a rectangular figure is marked on the skin with the lesion in the center and 1 cm. of normal skin between each of its sides and the edge of the lesion. A lead tube with a cross section of 8 mm. and walls of 2.5 mm. containing radon is used for treatment. The active length of the tube is equal to one side of the rectangle and its linear intensity is 10 millicuries. Parallel to the side concerned, lines are drawn 8 mm. apart. The tube is covered with strapping and applied along the side of the rectangle. The next field to be treated is the space between this line and next, and so on for the others. For most lesions, the exposure is two hours for each field except the two outer ones, for which it is two and one-half hours. After every third exposure the radon tube is made up to its original intensity The results are good and the technic has the following advantages (1) The tube since it contains radon, can be made of any length required. (2) The patient can be treated in two or three days without hospitalization (3) The reaction is slight and does not keep the patient from work."

Albright (3) employs irradiation therapy as follows "Lesions up to 3 cm. in diameter, including those of the lip, are implanted with radium element needles, either six needles each of 10 mgm. strength or eight needles each of 3 mgm strength, using 0.5 mm. platinum filtration One treatment of usually not more than four hours is required This gives a total dosage of 6 needles × 10 mgm each × 4 hrs., or 240 milligram hours. This is followed by hyperemia, local swelling, leading to ulceration in ten days, at which time beginning re-epithelialization is evident. By the end of three to four weeks epithelialization should be complete. The end result should be a soft, stable scar, often whitened due to loss of normal epithelial pigmentation Any persistent induration after six weeks must be strongly suspected as tumor, requiring additional treatment of less intensity This general method of treating cancer of the skin of the face, including cancer of the lip has been standardly employed at the Radium hemmet, Stockholm, since 1926 Lesions larger than 3 cm. in diameter have been best controlled by either surface x-irradiation (i.e. 7 to 10 S E D via x ray with light filtration of 1-2 mm aluminum, and careful screening of the surrounding tissues, or

via the 5 gm teleradium bomb at 3 cm distance, giving a depth dosage of 2 cm). The method of introducing the needles is shown in Figure 892.

Diathermy. The cancerous growth may be destroyed by diathermy Rowlands and Turner (104) state that "the effect of diathermy differs from that of the actual cautery in that the superficial effect is less and there is no actual charring, but the penetration is much deeper, so that heating and coagulation of the tissues takes place for some considerable distance beneath the smaller electrode Morbid tissues and cells appear to be very much more readily destroyed than the normal tissue The mode of procedure is to remove as completely as possible all the malignant tissue Bleeding is then checked by pressure with hot pads of gauze and the small electrode is then systematically applied to the whole area, care being taken that the electrode does not remain in contact with any one spot for an undue length of time When obvious masses of malignant disease are present the coagulation must be more thorough than in less advanced cases, where the main mass can be removed with knife or curette The risk of injuring important structures, though slight, must not be lost sight of, and

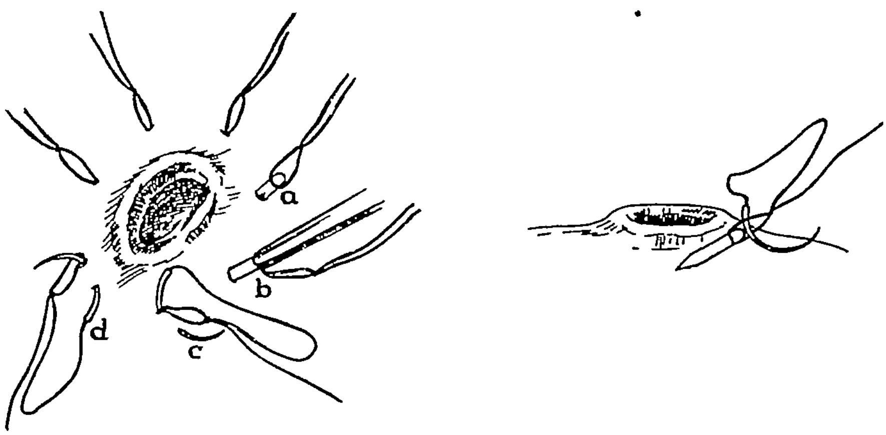


FIG 892 Method of introducing radium element needles *a*, needle introduced through small puncture. *b*, needle forced into tissue with forceps *c–d*, needle in place Insert shows position of needle in tissues and method of securing it. (Rowlands and Turner)

in cases where large and important vessels lie close to the malignant mass it is wiser to stop short of actual coagulations There is some risk of secondary hemorrhage, but this is less than might have been expected from the nature of the cases in which diathermy is used"

Cauterization. Destruction of the growth by chemical cauterization is less popular at present than in former years Broders (13) found that treatment with pastes, plasters, etc, greatly lessened the patient's chance of ultimate recovery, metastasis being twice as common in cases that had been so treated The agents most frequently used are zinc chlorid, arsenic paste, and pyrogallol The latter in the form of 10 per cent ointment is recommended by Kaposi The technic for the application of these substances belongs properly to the domain of dermatology and will not be discussed here

PIGMENTATIONS OF SKIN

The following classification of skin discolorations will assist in the choice of the appropriate method of treatment:

Group I Discolorations due to the deposit of iron-free pigment in the epithelial

cells. A common example of this type of pigmentation is that which follows exposure of the skin to the sun's rays or to irradiation therapy *Group II* Discolorations due to the introduction of pigment into the skin from without, the coloring matter being either deposited at the point of innoculation—as, for instance, in tattoo marks or carried by the blood stream—as, for example, in the skin pigmentation following the ingestion of silver, arsenic, mercury, or lead. *Group III* Discolorations due to deposits of iron-containing pigment derived from the blood—for instance, the discoloration which follows endocrine disturbances, constitutional diseases, and neoplasms.

In the first group where the stain is limited to the upper layers of the skin, any agent capable of causing desquamation of the epidermis will remove the pigmentation, the new unpigmented cells taking the place of the old discolored epithelium. An effectual application is one such as the following Resorsin 7.5 gm , salicylic acid 3 7 gm., lactic acid 3 7 gm., and alcohol q.s.ad 30 gm. The solution is rubbed into the affected areas 2 or 3 times at 10-minute intervals. The subsequent inflammatory reaction will be followed in about a week by desquamation of the epithelium, and the underlying skin will be found pigment free

Various bleaching preparations have been advocated, such as the following (99) "Perhydrol, a 30 per cent solution of hydrogen peroxide, may be used as follows perhydrol, 2 cc., wool fat, 12 Gm., petrolatum, sufficient to make 20 Gm Apply this to a small area once daily until an inflammatory reaction occurs then stop it and wait for the dermatitis to subside. After this area is somewhat lighter, treat another in the same way If there is no result, the ointment can be made stronger

"The Jansch bleach, ammoniated mercury, bismuth subnitrate and barium sulfide of each 1 part, ointment to 30 parts may be spread on the area and allowed to remain over night. Strong applications are not advisable for fear of adding to the pigmentation. No definite length of time can be given, but cautious work will require several months at least, if the preliminary trial is satisfactory enough to warrant further treatment."

In the types of discolorations included under Group II the pigment deposits may be in the epidermis or in the corium, and *they may be effaced either surgically or chemically* The former is the method of choice when the pigmented areas are minute and scattered, such as in gunpowder marks or long narrow tattoo lines.

Small scattered tattoo marks may be removed with a Watson Keyes punch or a fine cataract knife, the diminutive wounds being closed by means of fine sutures. Lindsay (69) uses the following technic in the removal of deep particles of stain or powder Having selected a small tattoo spot to be removed, the operator renders the area as aseptic as possible and puts tension on the skin with one hand while he cuts carefully around the tattooed powder spot to a depth slightly deeper than the powder stain has penetrated. When two thirds of the circle has been completed it is advisable to seize this portion within the area of the horseshoe-like cut by means of the fine splinter forceps to steady it, while the cutting of the far side of the area and the underneath is completed. It is a good plan to remove all the powder grains at first and the stains at subsequent sittings. Most large areas can be divided up into numerous smaller areas, each bound by healthy unaffected skin. It is seldom, indeed that a suture is required to close a wound. The finest linen is most satisfactory for sewing the skin when necessary but should be removed within three days. If

only the face is involved, I prefer to cover the area with an antiseptic powder and leave it exposed to the air as much as possible "

Tattoo marks which do not exceed 2 5 cm in width may be excised in the form of an ellipse and the margins approximated directly after undercutting Larger marks up to 10 cm in diameter can be removed by a series of partial excisions The technic is described on page 1373 Briefly, a central area about 2 5 cm in diameter is excised in the form of an ellipse, and the margins are sutured together When the elasticity of the skin has been re-established, the process is repeated until eventually the entire mark has been eliminated If the area exceeds 10 cm in diameter, the portion of corium containing the pigment may be shaved away with a razor and resurfaced by means of a skin graft

Tattoo marks may be removed chemically, according to the method of Variot (117), as follows. A 50 per cent solution of tannic acid is tattooed into the pigmented area For this purpose an ordinary needle may be used, or, better still, a fine drill driven by a dental engine The needle or drill is applied perpendicularly to the surface and is worked back and forth across the design, with just enough pressure to macerate the epithelium and deposit the solution deeply in the corium, but not beneath it The tattooed area is then painted with silver nitrate, so that silver tannate is formed, and finally the residue is rinsed off with sterile water An ordinary dressing is then applied for 2 or 3 days Upon its removal the tattooed area will be found hard and dry In 10 days to 2 weeks the dry black slough falls away, leaving a pink surface underneath, which eventually assumes the color of the surrounding skin A solution of 30 parts of zinc chlorid and 40 parts of water has been used for a similar purpose

The treatment of the different types of pigmentation listed under Group III will depend upon the causative factor, and as this is more of a medical than a surgical problem, it will not be discussed in these pages

Areas of deficient pigmentation can by artificial means be made to assume the color of the surrounding skin This is accomplished by tattooing into them non-toxic pigment, such as carmin, indigo, vermilion, or cinnabar The tattooing is done with an instrument consisting of an ordinary holder carrying from 3 to 6 fine needles set closely together The dye is pricked into the skin to a depth of not more than 0 5 mm If the color is carefully selected, a fairly good match may be obtained

WRINKLES

Pathologically, there are two types of aging facial skin (1) a hypertrophic variety, with or without fatty infiltration, and (2) an atrophic variety In the *hypertrophic type* the process probably begins in the scalp with an atrophy of the areolar tissue and glandular elements These changes, together with the gradual diminution of the skeletal and muscular volume characteristic of advancing age, cause the scalp to become too large for the cranium, and in consequence the skin gravitates over the lower parts of the face Along the symphysis, however, the skin is firmly adherent and does not share in the sagging process, giving rise to the so-called tricornered chin Along the nasolabial grooves the weakened connective tissue fibers break and, where they adhere to the subjacent tissues, they form deep wrinkles, appearing as trenches separating the mouth from the overhanging cheeks The skin of the eyelids becomes thin and lies in folds, that of the upper lids often hanging below the lid margins and

that of the lower forming pouches beneath the eyes. *Pari passu* with the sagging process, the subcutaneous fat becomes redistributed, disappearing in the upper region of the face and accumulating in the lower part. The facial muscles undergo fibrous and exert undue tension on the skin to which they are attached Thus transverse wrinkles appear across the forehead over the course of the epicranius, two vertical wrinkles form between the eyes over the corrugator and the pyramidalis, and at the outer canthi a fan-shaped arrangement of fine lines develops over the muscles inserted into the orbicularis oculi. The skin over the masseter muscle may present a vertical wrinkle along its anterior border Around the mouth there forms a characteristic arrangement of lines due to the fan-shaped insertion of the muscles into the orbicularis

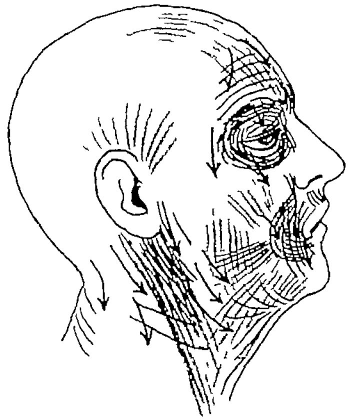


FIG. 893 Senile wrinkling of face in relation to underlying muscles. Arrows indicate direction of ptosis.

oris. The zygomaticus which normally raises the corner of the mouth and deepens the nasolabial fold and the depressors of the angle of the mouth which draw the orbicularis downward and depress the lower lip likewise become fixed and give rise to characteristic wrinkles. In the neck the fibrosis of the platysma causes the cheeks to hang down like "dewlaps." During forced contraction fibrous cords stand out in ridges, and in periods of relaxation the skin below the mandible either sinks as a pure redundancy or becomes "doubled" from the accumulation of fat (fig 893)

In the *atrophic type* the skin assumes a lusterless tinge of yellow, brown, or green, and telangiectactic blood vessels can be seen coursing beneath its surface. It is at first dry and harsh, due to atrophy of the sebaceous and sudoriferous glands, later it becomes thin smooth, and glossy, as a result of degeneration of the hair follicles, and in time it assumes the appearance of dry, rumpled tissue paper with a loss of

resiliency, owing to degeneration of the elastic fibrils, so that when it is picked up between the fingers, the fold tends to remain. Non-elevated pigment patches of a yellowish brown color frequently develop. (This hyperfunction of the pigment during the course of a general atrophic process is difficult to explain.) Microscopically, the epithelial layer shrinks to a few rows of cells, the prickle-cells undergo atrophy, and in the corium the white fibrous tissue proliferates and the elastic fibers degenerate, each fiber appearing swollen, shredded, and broken.

Surgical Management

Operations designed for the removal of wrinkles are of comparatively recent origin. As stated previously, the use of paraffin introduced by Gersuny (47) for this purpose in 1899 gave spectacular results, and it was not until experience demonstrated its harmful effects upon the unfortunate individuals who were subjected to the treatment that the practice was abandoned and attention was turned to surgery. Lexer operated for this condition as early as 1906, but the first reported case was that of Hollander in 1912. Passot (1919) and Joseph (1921) also devised operations for the elimination of wrinkles, and similar technics with modifications were soon reported by Noel, Stein, Eitner, Deselaero, Logarde, Smith, Kromayer, and others.

Opinions differ as to the advisability of operative measures. Some surgeons refuse to operate under any circumstances, feeling that wrinkling of the skin, like graying of the hair, is a normal concomitant of advancing years and that operative intervention merely panders to the patient's vanity and is not justifiable. Others, however, feel that for economic and psychiatric reasons, especially when the wrinkling occurs prematurely, such as that following radiotherapy and in the case of multiple small scars that cannot be excised, it is often an indicated procedure. In this connection Gillies (48) states: "The desire to look young and attractive is no prerogative of any one class. The world is made up of a penn'worth of all sorts, and it is not everybody's good fortune to grow more graceful and beautiful in advancing age. The operations for removal of eyelid wrinkles, cheek folds, and fat in the neck are justifiable if the patients are chosen with honest discrimination."

With the indication for operation so debatable, the decision to operate cannot be left to the whim of the patient, despite the minor character of the procedure. The surgeon must critically study each individual, both from plastic and emotional standpoints, with a view to determining whether operative intervention will be of actual benefit. Baker and Smith (6) have made a study of the personality of patients coming to the Graduate Hospital of the University of Pennsylvania for plastic repair of facial disfigurements. They divide them into three main groups, thus: Group 1, a superior class consisting of well-adjusted persons who offer ideal material for obtaining successful results. Group 2, including individuals with recessive or inadequate personalities who use their disfigurement as a defense mechanism. Group 3, prepsychotic and psychotic persons in whom the facial disfigurement is the factual point of focus for the schizophrenic process. It is the latter group "which forms the exasperating, disturbing chore for the surgeon who has obtained an excellent technical result. Such patients make the surgeon realize that his responsibility includes 'the person' as well as the operative field. Because of this, psychiatric aspects must be considered by the surgeon in working for complete and satisfactory results. It is the duty of the psychiatric

service to aid the surgeon in helping to spot such potential reactions. Any plastic or reconstruction procedure only serves to interrupt the rationalization process, and soon the resulting scar or some other trivial defect is seized on for continuation of the delusional and illusional construction which is often frankly schizoid. When such patients appear for surgical aid, one is wise to proceed with greatest caution and it is suggested that physiologic function alone be used as the criterion for operative intervention" The essayists suggest that for the recognition of these types certain questions be kept in mind "(1) What was the personality prior to the disfigurement? (2) What was the patient's emotional status when he was first conscious of his disfigurement? (3) What part has the disfigurement played in formation of the present personality? (4) What will probably be the emotional effect of plastic removal of the facial defect?"

Before surgery is undertaken, the patient should be informed as to the probable advantages of the procedure and their duration, as well as the potential complications. In those with the atrophic type of skin, in whom the nasolabial folds are deep and attached to the subjacent tissues, operation frequently falls short of giving satisfaction, inasmuch as a mere stretching of the skin cannot be expected to correct the atrophy and restore the continuity of the ruptured adherent connective tissue fibrils. Likewise, in the type characterized by fatty infiltration with irregular deposits of fat between the angle of the mouth and the lobule of the ear, the benefits are too transitory to justify the inconvenience of operation, as the fatty deposits will reappear within a period of weeks or months and destroy any primary beneficial effects. The most promising results may be expected from those individuals whose skin hangs in folds and shows a minimal destruction of the elastic fibrils, no scars, and but little fatty infiltration. As far as the duration of the results is concerned, the patient should be informed that the immediate effect is always good, but that after a variable period, depending upon age, profession, living conditions, mental habits, and hereditary predisposition to skin degeneration the redundancy will recur and necessitate a repetition of the operation. The average duration of the beneficial effects, even with the best technical skill, cannot be expected to exceed 3 or 4 years. The effects of subsequent operations, however, are likely to be less transitory, since after each surgical procedure the elasticity of the skin is reduced. This probably accounts for the more lasting results of such operations in older persons.

Each individual presents an entirely different problem, and no single plan of repair will be applicable in all cases. Therefore, before embarking upon the operation, the surgeon should carefully study the case in hand and formulate an exact plan of procedure. A general idea as to the amount of tissue to be excised can be obtained by placing the patient in front of a mirror and stretching the skin upward and backward in various planes and noting the effect of this or that manipulation on the forehead, eyelids, cheeks, nasolabial folds, and neck. If the final scar is to be inconspicuous, the incision must necessarily be placed at some distance from the deformity, and since this entails a considerable amount of undermining—the greatest hazard in this type of operation—the difficulty lies in selecting a site for the incision which will conceal the scar and at the same time reduce the amount of undermining to a minimum. For the effacement of wrinkles limited to the upper part of the face the incision can easily be hidden within the hair line of the temporoparietal region, and for those about the angles of the mouth

and neck it can be concealed behind the ear and in the occipital scalp But for the elimination of those of the cheek itself the problem becomes more difficult Here the interposed auricle, because of its firm attachment to the skull, would render ineffective any attempt to conceal the scar in the hair line, and it offers the further disadvantage of being too mobile in itself to furnish adequate support for the flap With a view to overcoming these difficulties, numerous incisions have been devised

Joseph's incision begins in the hairy scalp of the temporal region 9 to 10 cm. above the upper pole of the ear and is carried down along the inner surface of the anterior border of the auricle to the lobule From there it is continued upward behind the auricle and is terminated in the occipital scalp (fig 894) A vertical strip of skin of

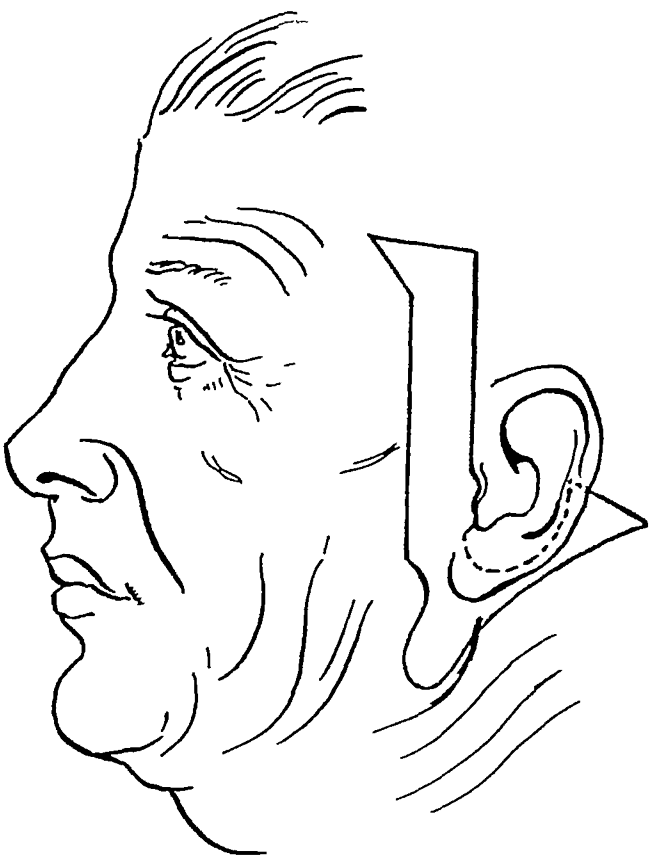


FIG 894 Joseph incision for removal of redundant skin about face For details, see text.

the appropriate size is then removed from in front of the ear As a precaution against buckling, two triangles are excised at the upper and lower extremities of the incision, the apex of the upper triangle pointing forward and that of the lower directed backward The skin of the cheek is undermined, drawn upward and backward, and the skin margins are united The result of this operation is transitory, as it contemplates merely a skin excision and provides no definite points of fixation A further objection to the procedure is the tendency on the part of the lobule of the ear to become distorted as the scar contracts

Lexer, in an effort to eliminate a visible scar in front of the ear, made two S-shaped incisions, one within the hair line of the temporal region, extending to the upper pole of the auricle, and the other beginning at the lower margin of the lobule and directed obliquely upward behind the auricle into the occipital scalp (fig 895) Through the

S-shaped incision above the ear the skin anterior to the incision is undermined and drawn upward and backward until the wrinkles on the upper part of the face are effaced The drawn up flap is secured temporarily to the margin of the wound by means of towel clamps or 1 or 2 sutures, and the excess tissue overlapping the line of incision is excised in the form of an S-shaped segment. The temporary sutures are then removed, and the deep surface of the flap is fixed with catgut sutures to the temporal aponeurosis, after which the apposing skin margins are accurately united by interrupted sutures of silk. The anterior flap of the posterior incision is likewise undermined and drawn backward and upward in such a manner that the wrinkles of the lower face and upper neck are obliterated, and the redundant skin is excised in a similar manner With the flap in place, its deep surface is fixed by sutures to the

FIG 895 Lexer incision for removal of redundant skin. For details, see text.

mastoid aponeurosis and periosteum, after which the skin margins are united in the usual manner It may be necessary to remove additional small triangles, as a precaution against buckling The wound is dressed with silver leaf covered with gauze. To relieve tension on the suture line during healing, strips of adhesive are attached to the cheek and anchored to the head, as illustrated in Figure 600 While this operation leaves no conspicuous scar, the fixation thus afforded is not sufficiently secure to assure permanent results.

Ehrenfeld (34) operates in a manner similar to Lexer and Joseph but modifies the incision in the following manner (fig 896) An incision is begun within the hair line of the parietotemporal region and carried horizontally to a point above the auricle From here it is continued vertically downward along the preauricular groove to the

upper margin of the tragus and from here along the inner surface of the ear to a point just below the tragus

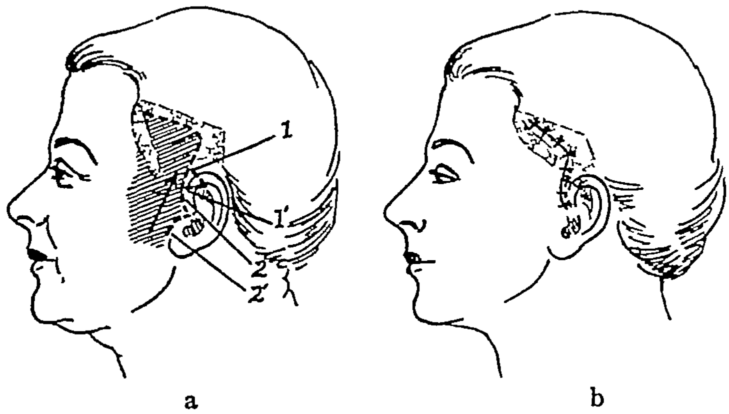


FIG 896 Ehrenfeld rhydectomy *a*, dotted line indicates incision, shaded area, amount of undermining Point *1'* sutured to *1*, and *2'* to *2* *b*, operation completed

Mornard (81) makes a long oblique incision beginning within the hair line almost at the point of union of the temporal, frontal, and parietal regions From here it is carried obliquely downward to the upper attachment of the auricle, then down along the preauricular groove to enter the auricle and follow the inner edge of the tragus to the point of attachment of the lobule to the face Behind the lobule it passes upward over the mastoid process and arches into the occipital scalp

Operative Technic

In operations designed for the eradication of facial wrinkles the problems are. (1) to determine the amount of tissue which must be excised in order to obtain the desired effect without causing the patient's face to assume the fixed expression of a wax figure, (2) to hide the line of incision and at the same time minimize the amount of undermining, and (3) to secure the flap to some point that will permit of sufficient anchorage to prevent a recurrence of the redundancy. These objectives can best be accomplished by recourse to the procedure about to be described

Instruments. The necessary instruments include. a syringe with a long and a short hypodermic needle, 2 Bard Parker knives, 1 equipped with #10 blade for the skin incision, and 1 with #15 blade for undermining, 4 dural hooks, 6 towel clamps, 1 straight and 1 curved pair of blunt-end scissors, 6 to 10 mosquito hemostatic forceps, a needle holder, several small half-round atraumatic needles mounted with waxed silk for skin suturing, larger needles for deep subcutaneous suturing, a head mirror; and a loupe

Preparation and Anesthesia. The hair along the prospective line of incision is shaved, a drop or two of sterile castor oil is introduced into the eyes, the auditory canals are packed with sterile tampons, and the skin is prepared in the customary manner (p 5) The head is then draped in such a way that the face is exposed to full view, and the parts are anesthetized General anesthesia is contraindicated, as it abolishes the powers of facial expression and prevents the observance of the effects of this or that traction, thus interfering with judgment in the reconstruction Satisfactory analgesia is obtained by infiltration with a 1 per cent solution of procain, 30 to 60 cc.

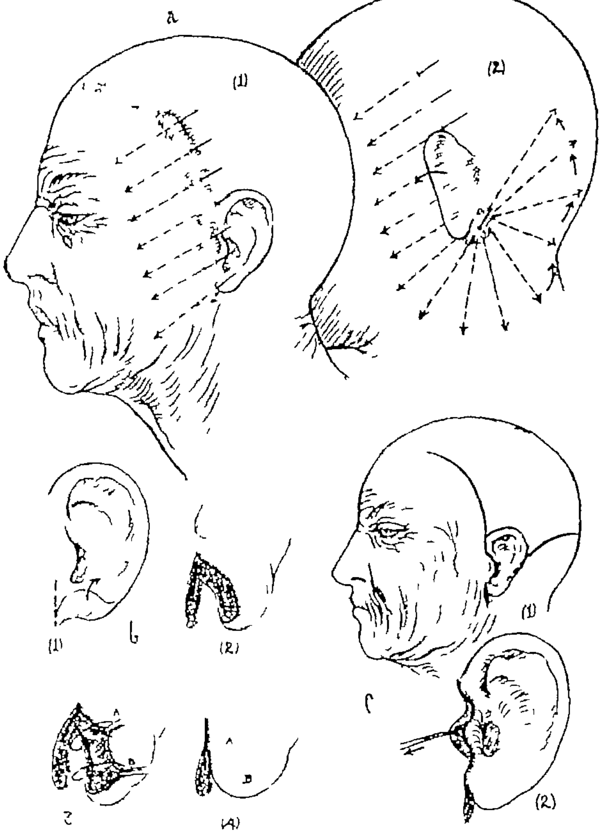


FIG. 897 Technic of rhydectomy *a*, anesthesia *1* series of parallel infiltrations made 1 to 2 cm. apart, beginning in temporal region and extending to lobule of ear *2*, neck and occipital scalp infiltrated. *b*, detachment of lobule *1* incision made. *2* subcutaneous tissue of lobule excised in form of trough. *3*, anterior margin left wider and thicker so that scar will be concealed posteriorly *4*, margins of lobular wound approximated, showing scar placed posteriorly *c1* incision beginning 2.5 cm. within hair line, carried to helix, along border of tragus to end opposite site of previously detached lobule; thence behind ear into parieto-occipital scalp. *2* incision outlined in front of auricle.

usually being sufficient Epinephrin is best omitted, as it leads to postoperative congestion and predisposes to the formation of hematomata A long needle is introduced into the skin of the temporal region within the hair line, and the tissues are infiltrated horizontally to a point in front of the lateral canthus A series of parallel infiltrations 1 to 2 cm. apart are then continued down in front of the auricle, to a point opposite the lobule, each infiltration being carried across the cheek halfway to the nasolabial fold Finally, the needle is introduced at the site of attachment of the lobule to the face, and with this point as an axis, the tissues of the angle of the mandible, neck, and occipital scalp are infiltrated in a radial manner (fig 897-a).

Detachment of Lobule. The first step in the operation is to remove the lobule from the line of incision, so as to prevent its subsequent displacement when the scar contracts The technic is essentially similar to that employed for the correction of an attached lobule (p 945) An incision is begun just below the incisura intertragica anteriorly and continued beneath the lobule, ending at a corresponding point on its posterior surface The lobule, thus detached, is elevated from the face with a dural hook and the skin margins are united with interrupted sutures of horsehair (fig 897-b) Approximation of the lobular edges will be facilitated if some of the intervening subcutaneous tissue is excised in the form of a trough, and the scar can be concealed posteriorly if the anterior margin is left slightly wider and thicker than the posterior one

The Incision. With a sharp scalpel an incision penetrating skin and subcutaneous tissue is begun in the temporoparietal region 2 5 cm within the hair line and is carried down to the upper attachment of the helix to the face From here it is directed horizontally across the preauricular groove to the upper margin of the tragus, where it enters the auricle and passes along the posterior margin of the tragus, ending at the point of the previous detachment of the lobule From here it is carried upward behind the ear into the parieto-occipital region as far as is deemed necessary The incision when completed takes the form of a V, one limb lying anterior and the other posterior to the auricle (fig 897-c)

Detachment of Flaps Hemorrhage having been controlled, the anterior lip of the incision is undermined in the plane above the fascia Under no circumstances should the fascia be penetrated, as such an accident would endanger the facial nerve, parotid gland, and parotid duct The extent of undermining is regulated by the amount of rotation necessary to overcome the wrinkling Ordinarily, it is carried anteriorly halfway to the outer canthus and to the anterior border of the masseter muscle (fig 898-d), below, to the angle of the jaw, and posteriorly far enough to overcome the sagging of the neck skin (fig 898-e) Around the sternocleidomastoid muscle it will be necessary to cut the fibrous septa extending from the aponeurosis to the skin (fig 898-e) More extensive undermining is neither advisable nor necessary, as it opens blood vessels which are inaccessible to ligation and leads to the formation of hematomata Hemorrhage, which is quite free, is due principally to severance of the 5 or 6 arteries which emerge from the parotid fascia These vessels should be ligated with the finest of silk ligatures Bleeding from smaller vessels may be controlled by means of clamps or the application of hot compresses In any case hemostasis must be complete, as the collection of blood beneath the skin may lead to disturbing consequences

Rotation of Flaps and Removal of Excess Skin When the skin has been completely detached from the underlying fascia, the anterior flap is grasped with several

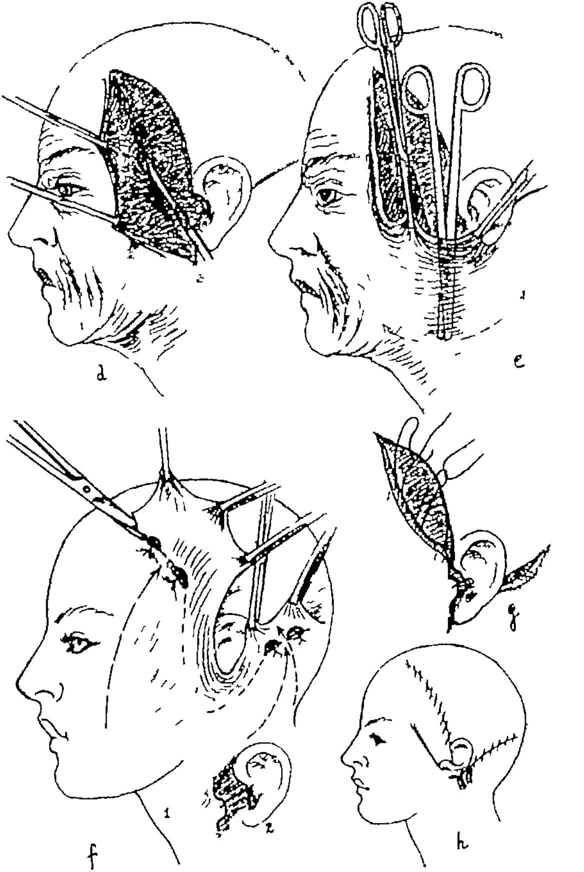


FIG. 898. Technic of rhydectomy (cont.) *d*, anterior skin flap undermined in plane above fascia halfway to lateral canthus and to anterior border of masseter *e*, undermining continued below mandible around sternomastoid Fibrous septa between aponeurosis and skin cut. *f1* rotation of flaps anterior flap grasped with hemostats and rotated through arc upward and backward, until wrinkles about forehead, eyes, and upper part of face are eliminated Flap fixed temporarily to margins of incision by a few sutures. Posterior flap rotated upward and forward, until wrinkles of lower face and neck are effaced, and fixed in like manner When flaps are adjusted satisfactorily excess tissue overlapping margins excised with scissors. *2* in region of tragus, flap fashioned to replace sacrificed tragal covering. *g*, fixation of flap deep surfaces of flap secured to fascia and to zygomatic, mastoid, and cranial periosteum by sutures so placed as to draw mobilized skin upward and backward. *h* approximation of skin margins. sutures so passed that bite in skin flap lies at lower level than that in wound margin, so that when tied flap will be drawn upward. Drainage tubes inserted at lower angle of wound.

hemostats or hooks and rotated through an arc upward and backward until the wrinkles about the forehead, eyes, and upper part of the nasolabial folds are obliterated. It is then fixed temporarily to the margin of the original incision by means of 2 or 3 small towel clamps or sutures (fig 898-f) The posterior flap is then rotated upward and forward until the wrinkles about the lower part of the face and neck are effaced, whereupon it is fixed temporarily to the posterior wound margin in a like manner (fig 898-f). At this point in the procedure an idea may be had of the final effect If necessary a little more undermining may be carried out or the line of traction altered by a change in the position of one or more clamps While a slight overcorrection is advisable to compensate for subsequent relaxation of the tissues, care should be taken not to efface the normal lines of expression.

When the flaps have been adjusted to the satisfaction of the operator, the excess tissue overlapping the margins of the incision is excised with a knife or a pair of strong straight scissors (fig 898-f) In the region of the tragus the flap should be fashioned in such a manner that it will replace the original tragal covering which has been sacrificed In order that the skin may lie smoothly over this area, the edges are thinned by the removal of more or less subcutaneous fat (fig 898-f)

Fixation of Flaps. Before the skin margins are coapted, the deep surfaces of the flaps are secured to the inelastic fascia and to the zygomatic, mastoid, and cranial periosteum This is probably the most important step of the operation, as the permanency of the results will depend largely upon the care with which this is carried out An added advantage of such fixation is that it serves to obliterate dead spaces and eliminate tension on the skin edges The technic is as follows: The towel clamps previously placed are removed from the anterior flap, and a half-curved needle threaded with fine white waxed silk is made to take a bite of the fascia, withdrawn, and then passed through the under surface of the flap at a point lying anterior and inferior to the fascial bite (fig 898-g), so that when the suture is tied, it will draw the mobile skin upward and backward Such sutures are passed from the flap to the temporal fascia, epicranial aponeurosis and periosteum, zygomatic fascia, and parotid fascia When all have been passed, they are tied from below up (fig 898-g), the effect of each suture being noted and the stitch readjusted if necessary before tying the next one The clamps on the posterior flap are then removed, and similar fixation sutures are placed between the under surface of the flap and the mastoid fascia and underlying periosteum Fine silk is the ideal material for the purpose, for it causes no reaction in the tissues, in time becomes incorporated by fibroblasts, and, according to Halsted, is ultimately absorbed If catgut is employed, fewer stitches must be passed, since this material sets up a reaction in the tissues

Approximation of Skin Margins. After the fixation sutures have been tied, the skin edges fall into easy approximation and are united with interrupted sutures of horsehair or fine silk on an atraumatic needle Each suture is placed in such a way that it lies obliquely across the line of incision, the bite in the skin flap being on a lower level than that in the wound margin, so that when tied the flap will automatically be drawn upward. The suturing is begun from below and is carried upward both in front and in back of the auricle, care being taken to avoid the incorporation of fat in the suture line, as this poorly nourished tissue has a tendency to undergo necrosis At the upper extremities of the incisions buckling is overcome by the removal of triangular sections

Fig 899 Results following rhydectomy

of skin after the method of Burow (p 235) During the suturing of the skin margins within the tragus special care must be taken to avoid distortion of the tragal covering. Some advocate the use of button-sutures for closure of the wound but these are unnecessary. A wound requiring such support suggests undue tension, and a stitch mark may remain, even though the button prevents the tearing out of the suture.

The wrinkles on the opposite side of the face are treated in a similar manner. Throughout this stage of the operation frequent comparisons should be made with the corrected side for the purpose of securing symmetry It is seldom that both sides of the face are equally wrinkled Hence, it is usually necessary to remove a little more skin on one side than on the other.

When the operation has been completed, a drainage tube is introduced between 2 sutures at the lower angle of the wound and removed in 24 hours.

Dressing. The suture line is covered with a sheet of sterilized silver-foil, and this is overlaid with a gauze pad and a moistened marine sponge, held in place by a firm bandage carried around the head and incorporating the vertex and chin, several circular turns being made around the forehead. Such a bandage inhibits the collection of serum beneath the flap and reduces the edema about the eyes The patient is placed in bed with a sandbag on either side of the head and is instructed to rest quietly and refrain from talking or laughing A liquid diet is prescribed for a day or two Pain, which is usually negligible, can be relieved by the administration of the ordinary sedatives, such as luminal or pyramidon (p 492) Some swelling and edema is to be expected for the first 2 or 3 days, and this can be somewhat reduced by the application of ice bags to the part Any oriental distortion present about the eyes usually disappears in a day or two A rise of temperature of ½ to 1 degree is common and of no significance. The flaps should be inspected daily for evidences of hematomata, which if found should be immediately evacuated Stretching of the scar may occur if the skin margins have been sutured under too great tension, in such an event removal of the stretched cicatrix must be postponed until healing is complete A keloidal tendency can be counteracted by irradiation therapy

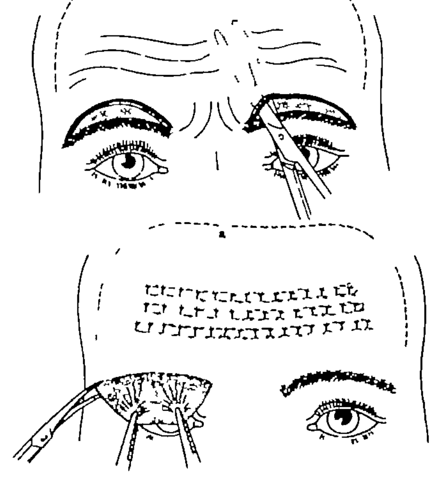
Removal of Sutures. As the sutures were placed without tension, those in the preauricular region may be removed as early as 48 hours after operation, the suture line being supported for several days thereafter by strips of gauze held in place with collodion The balance of the stitches, being hidden in the hair line and behind the ear, may be allowed to remain until the fourth or fifth day, at which time every other one is removed, and the rest on the following day (fig 899)

Forehead Wrinkles

For the eradication of horizontal wrinkles of the forehead Lexer and Joseph advocated the following technic (fig 900) An arched incision is made in the scalp 2 or 3 cm above the hair line and extending from one temporal region to the other, the extremities of the incision curving toward the auricle, or 2 separate arched incisions are made laterally, the central portion being left intact Through this incision or incisions the forehead tissues are undermined in the normal cleavage plane The amount of tissue to be excised is now estimated by the exertion of upward traction on the forehead flap, and the excess is removed with a scalpel or a pair of scissors. Hemorrhage is controlled by pressure The skin margins are then accurately united by on-end mattress-sutures of silk

a b

FIG. 900. Joseph operation for eradication of forehead wrinkles. *a*, elliptic section of scalp removed from above hair line. Forehead skin separated from epicranius. *b*, wound margins united under tension.



a

b

FIG. 901 Simultaneous eradication of forehead wrinkles and elevation of eyebrows. *a*, incisions made along upper margins of eyebrows Forehead skin undermined with blunt scissors, and fibers of epicranius cut. Dotted line indicates extent of undermining. *b* forehead skin drawn down, until wrinkles disappear Excess skin excised, and wound margins approximated. Forehead skin everted in horizontal folds along wrinkle lines and maintained in position by sutures passed through base of folds. Stitches removed in 24 hours

The relief afforded by this operation is only temporary, since the results depend entirely upon the amount of tension exerted on the skin in closure, and the action of the epicranius soon causes the wrinkles to recur. Furthermore, in individuals with a high forehead or a receding hair line the operation would obviously be out of the question

Inasmuch as forehead wrinkles are invariably associated with a drooping of the eyebrows, a more practical procedure which will eradicate both defects and at the same time leave an inconspicuous scar is the following (fig 901): An incision is made along the upper margin of each eyebrow, and through these openings the forehead skin is separated from the underlying structures with a pair of blunt scissors. As a precaution against recurrence of the wrinkles, it is well to sever the epicranial fibers subcutaneously After free mobilization the skin is drawn down over the original incisions until the wrinkles disappear The excess skin is excised and the wound margins approximated In order to eliminate the lines of ruptured connective tissue fibers, the skin is everted in horizontal folds along the lines of rupture and maintained in this position by means of several sutures passed through the base of each fold. These sutures are removed in from 24 to 36 hours (Slight elevations will remain at the sites of the previously depressed wrinkle lines, but these will smooth out in 2 or 3 days) Finally, the wound is dressed and a compression bandage passed around the forehead to limit edema and ecchymosis about the eyes

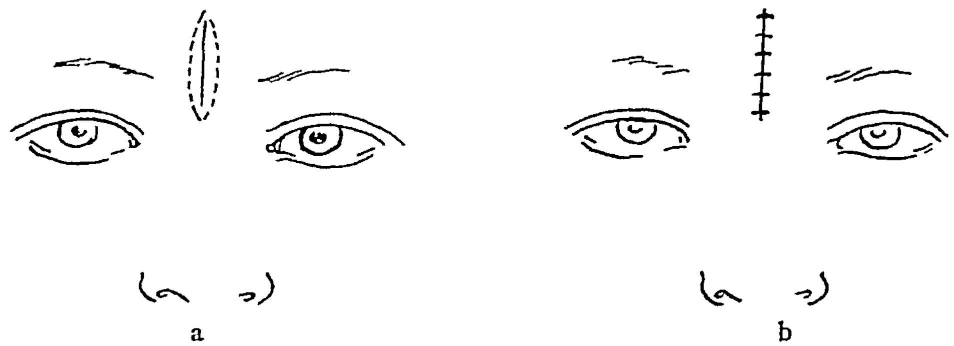


FIG 902 Joseph operation for eradication of glabellar wrinkles *a*, elliptic section of skin to be removed indicated by dotted line *b*, margins of resultant wound approximated

Glabellar Wrinkles

Glabellar wrinkles are of two types, vertical and fan-shaped The former occur singly or doubly above the root of the nose between the inner margins of the eyebrows and are due to a fibrosis of the corrugator muscle The latter spread from the root of the nose into the forehead over the course of the procerus The usual method of eradication is by means of an elliptic excision of the wrinkles, followed by accurate suturing of the margins (fig 902) The objections to this procedure are the remaining scar and the tendency of this region to undergo keloidal changes. A better plan, provided the connective tissue fibers are not ruptured, is to make an incision at the inner margin of one or the other eyebrow, undermine the skin over the glabellar region, cut the corrugator subcutaneously to prevent recurrence of the condition, and close the wound in the eyebrow. The wrinkles are then picked up in folds and held in this

position by means of external sutures. The stitches are removed in from 24 to 36 hours. The slight elevation that remains will disappear in a few days.

If the wrinkles are deep and the connective tissue fibers are ruptured, correction is best achieved by means of a graft, the transplant being introduced into a previously prepared bed through an incision at the inner corner of the eyebrow Fat grafts are on the whole unsatisfactory, as a varying amount of absorption always takes place, making an accurate estimation of the proper size of such a graft impossible. Fascia best subserves the purpose A strip of this material is cut into small segments 1 cm in diameter, and these are introduced one by one through a cannula into the previously prepared bed, until the desired effect is obtained (fig 903) The wound in the eyebrow is then closed

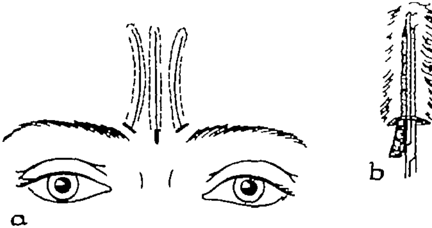


Fig 903 Eradication of glabellar wrinkles by fascia graft. *a* beds prepared through incisions at inner extremities of eyebrows *b* fascia graft introduced.

Eyelid Wrinkles

Lower Lids

Before operation for the removal of pouches in the lower eyelid is undertaken, bagginess resulting from constitutional conditions, such as kidney and heart disease must be excluded.

Pathologically, two varieties of lid pouches are recognized (1) Blepharochalasis, described by Fuchs (45) in 1896 and characterized by atrophy and stretching of the skin, the lids assuming the appearance of rumpled tissue paper Here a mere excision of the redundant skin will be all that is necessary to overcome the disfigurement (2) Ptosis adiposa, first described by Sichel and characterized by a senile relaxation of the fascial bands which connect the skin with the palpebral muscles and an atrophy of the tarso-orbital fascia. The weakened fascia is pushed forward by the orbital fat and in time gives way allowing the fat to protrude between the fibers of the orbicularis muscle, forming a pouch beneath the skin In this type a mere excision of the excess skin would fail to effect a permanent correction since the defect remaining in the tarso-orbital fascia would soon bring about a recurrence of the disfigurement.

In cases where the deformity is due merely to a redundancy of the skin the following procedure is employed (fig 904) With the lids temporarily closed by means of 3 silk sutures (p 839), the skin is lifted in a fold between the fingers, to estimate the

amount to be removed An incision parallel to the lid margin and 1 to 2 mm below it is then carried from canthus to canthus. The site for this incision is important, for if it is placed too high, there is danger of ectropion, and if too low, a visible scar will result Through this opening the skin is undermined for several millimeters Beginning at the inner canthus, the excess skin is excised in the form of a crescent which should not exceed 3 or 4 mm at its widest part. In the vicinity of the inner canthus very little skin should be removed, lest there follow an eversion of the punctum It is better to carry out a subsequent operation and excise another small strip than chance ectropion by the removal of too much at one time In order to prevent buckling and afford the necessary support to insure against ectropion, the upper incision is prolonged obliquely downward for about 1 cm , and the lower incision is extended to meet it The triangle of skin thus outlined at the outer canthus, having its base on the wound and its apex directed downward, is excised The edges of the wound are approximated with on-end sutures of horsehair or by a subcuticular suture of silk At the outer angle of the wound the lateral palpebral ligament should be

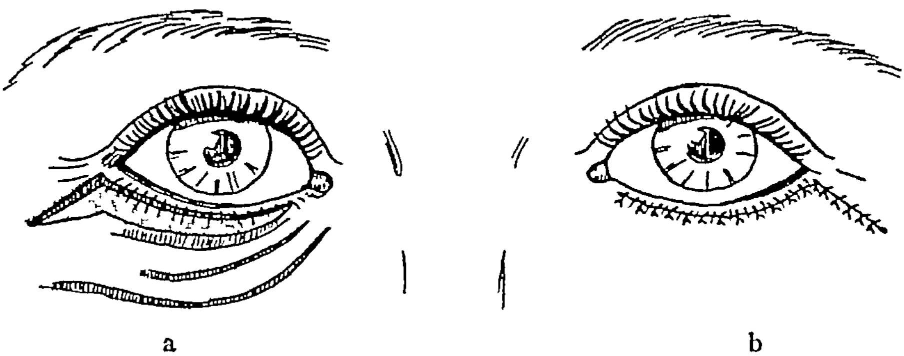


FIG 904 Surgical removal of lower lid pouches due to atrophy and stretching of skin. *a*, incision carried from canthus to canthus, parallel to lid margin and 1 mm below it Excess skin excised in form of crescent not exceeding 4 mm at its widest part Triangle based on wound excised at outer canthus, to assure against buckling and ectropion *b*, wound margins approximated, lateral palpebral ligament being incorporated in suture at outer angle of wound

incorporated in the suture, as a further precaution against ectropion. The suture line is painted with Whitehead's varnish, and the patient is instructed to wear smoked glasses for a day or two. The sutures can be safely removed in 24 to 48 hours, as there is no tension on the skin margins The scar, being hidden by the eyelashes, will be imperceptible

If the pouch is due to a herniation of the intra-ocular fat and there is no associated skin redundancy, the operation may be performed from the conjunctival surface and an external scar thus avoided With the lower lid everted and the eye protected with a horn plate, an incision is made along the lower conjunctival fornix The fibers of Mueller's muscle are separated to expose the herniated fat, which is then removed. In the event of an associated skin redundancy, an external incision is carried from canthus to canthus as already described, and the skin is undermined to expose the orbicularis oculi muscle, the fibers of which are bluntly separated until the tarso-orbital fascia comes into view (fig. 905). The herniated fat is removed, taking care to leave a sufficient quantity for the support of the eye The margins of the ruptured fascia are imbricated and sutured together with fine silk The redundant skin is then excised in the manner already described To insure against a recurrence of the

pouch, it is advisable that the under surface of the skin flap be attached to the tarsal cartilage with several sutures of fine white silk, so that tarso-orbital adhesions may form. Finally, the skin margins are coapted with a subcuticular suture of silk.

Sakler (105) employs fascia lata for the correction of this type of deformity and operates in the following manner "A horizontal incision is made through the skin and attenuated orbicularis 4 mm from the lid margin Traction-fixation sutures are now placed. One mattress silk suture is inserted through the skin and subcutaneous tissue of the upper lip of the wound at its center This suture is held by a small hemostat. Three silk sutures are inserted through the lower lip of the wound at its inner, central and outer portions. Traction on these fixation sutures allows a good exposure of the protruding fat. With a blunt curved Stevens muscle scissors the fatty mass is dissected free from the skin and fibers of the orbicularis anteriorly, and

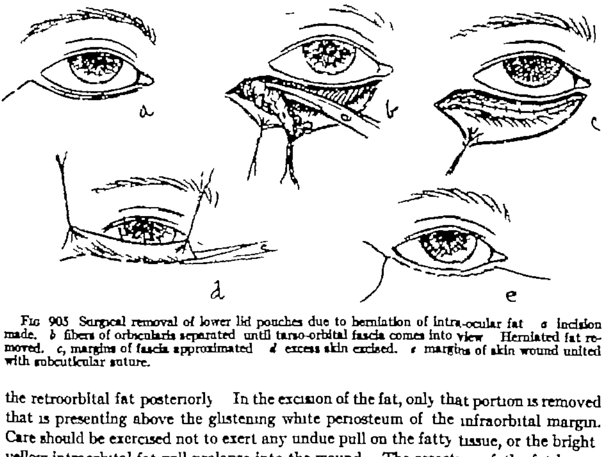


FIG 903 Surgical removal of lower lid pouches due to herniation of intra-ocular fat *a* incision made. *b* fibers of orbicularis separated until tarso-orbital fascia comes into view Herniated fat removed. *c*, margins of fascia approximated *d* excess skin excised. *e* margins of skin wound united with subcuticular suture.

the retroorbital fat posteriorly In the excision of the fat, only that portion is removed that is presenting above the glistening white periosteum of the infraorbital margin. Care should be exercised not to exert any undue pull on the fatty tissue, or the bright yellow intraorbital fat will prolapse into the wound The resection of the fat hernia is facilitated by the use of smooth curved Kelly forceps, bisecting the mass and then dissecting it free from the center towards either end Bleeding is controlled by fine catgut ligatures. Oozing is stopped by pressure Absolute hemostasis is essential. ' A fascia lata transplant is bisected into two strips "each measuring about 5 x 1 cm and trimmed to fit the space between the periosteum of the infraorbital margin and the convex border of the tarsus, loosely without tension The fascial implant is then sutured to the inner surface edge of the infraorbital periosteum below, and the distal convex margin of the tarsal tissue above, extending from inner to outer canthus. (Interrupted 20-day, 000-chromic-catgut sutures on a small curved round needle are used) The traction sutures are removed The skin incision is closed

with multiple interrupted fine-silk sutures Bichloride ointment 1:3000 is put into the conjunctival sac, and a pressure bandage applied. The first dressing is made in 24 hours The skin sutures are removed in four days "

Hollow depressions beneath the lower lid can be corrected by the implantation of a fascia graft beneath the skin through an incision just below the palpebral margin (fig 906). Or the orbicularis may be separated and a strip removed from the tarso-orbital fascia. This permits the retro-orbital fat to herniate through and fill out the depression The same procedure is applicable to the obliteration of depressions over the upper lid

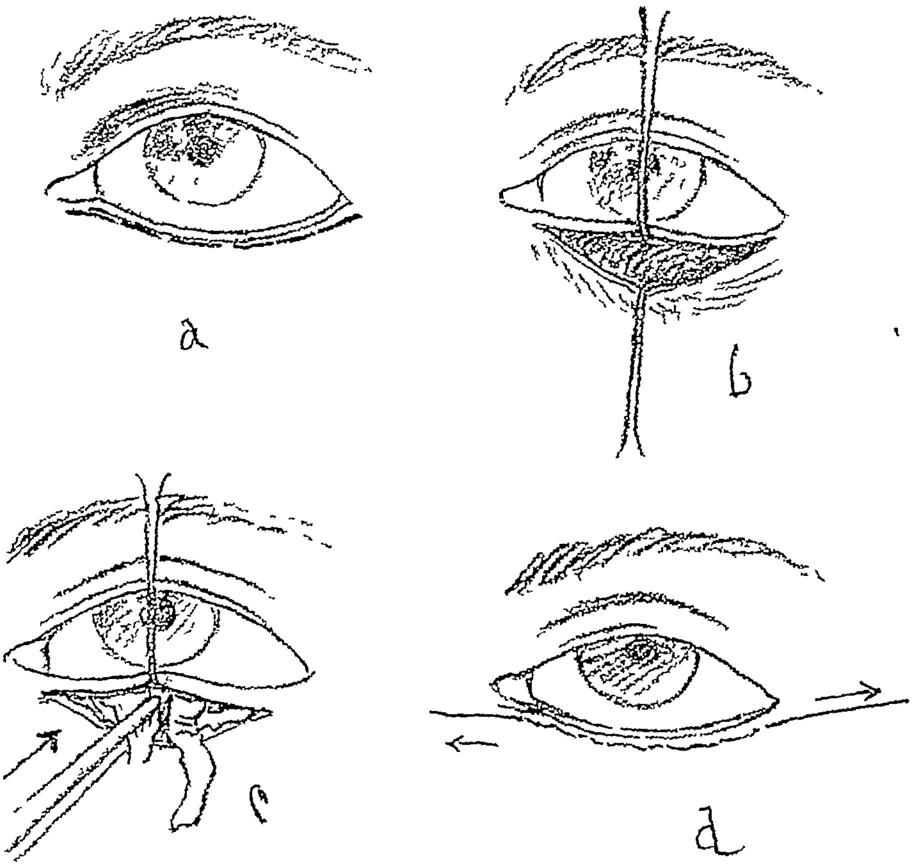


FIG 906 Building out of hollow depressions beneath lower lid by implantation of fascia graft *a*, incision made *b*, wound margins held apart. *c*, strips of fascia implanted *d*, wound closed with subcuticular suture

Upper Lids

Because of the scantiness of subcutaneous fat in the upper lid, wrinkles appear early in life in the form of numerous fine folds running parallel with the palpebral margin As a rule, they are less disturbing than those in the lower lid and require no treatment Occasionally, however, the redundant skin hangs over the edge of the palpebral fissure, or a tumorlike mass develops at the inner canthus as a result of a fat herniation through the thin tarso-orbital fascia These deformities are at times so marked as to cause interference with vision and require surgical removal Correction is accomplished in the same manner as that of similar disfigurements in the lower lid The skin incision, however, instead of being placed near the lid margin, is so planned that the scar will lie in a natural fold (fig 907) The results of these operations are excellent, and the danger of ectropion is slight

Wrinkles at Outer Canthus

Wrinkles in the vicinity of the outer canthus appear as a mass of fine lines radiating from the corner of the eye They are obliterated as follows (fig 908) An arched or S-shaped incision is made within the hair line in the temporoparietal region The

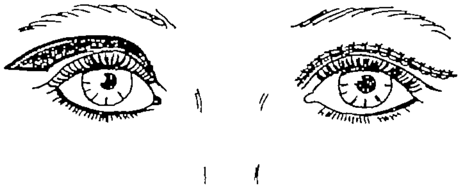


Fig. 907 Removal of redundant skin from upper lid a, semilunar segment of skin removed, excision being so planned that scar will lie in natural fold. b resultant wound closed with interrupted horsehair sutures.

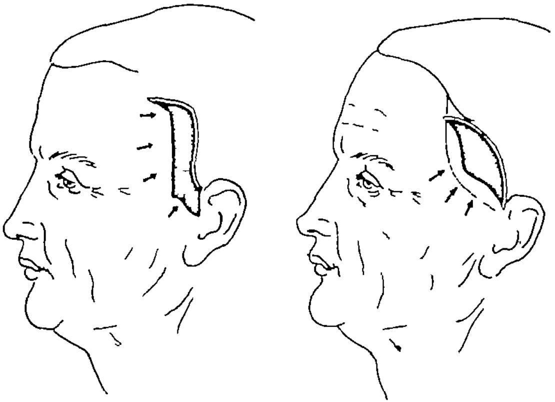


Fig. 908. Skin excisions designed for removal of wrinkles limited to outer canthus and upper cheek region. Anterior lip of wound undermined. Fasciculi attaching skin to orbicularis oculi muscle sectioned. Mobilized flap drawn upward and backward (as indicated by arrows) under tension sufficient to eradicate wrinkles Redundant skin excised Wound margins approximated. (Lexer)

anterior lip of the incision is undermined, and the fasciculi attaching the skin to the orbicularis oculi are sectioned. The mobilized flap is then drawn backward and upward under tension sufficient to eradicate the lines. The redundant skin is excised in the form of a semilunar spindle-, pear , or S-shaped segment, depending upon the

line of tension required It goes without saying that the same amount of skin must be removed on both sides if symmetry is to be attained Several subcutaneous catgut sutures are passed to relieve the strain, and the skin margins are approximated The scar will be inconspicuous, as it is hidden within the hair line

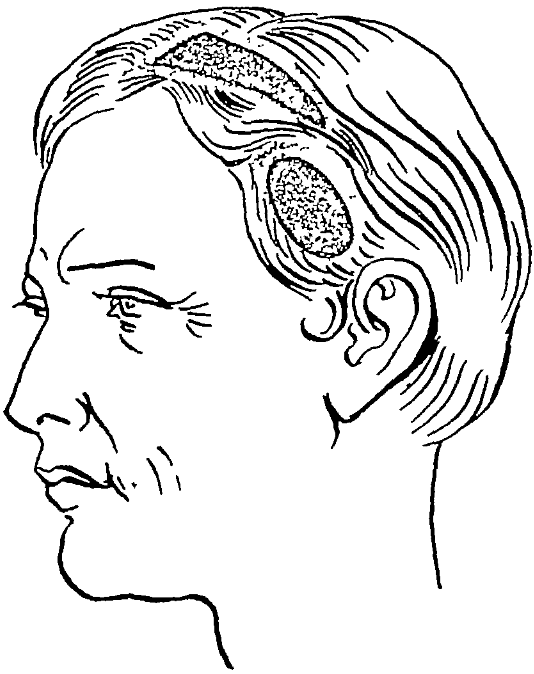


FIG 909 Noel's patterns designed to aid skin excision

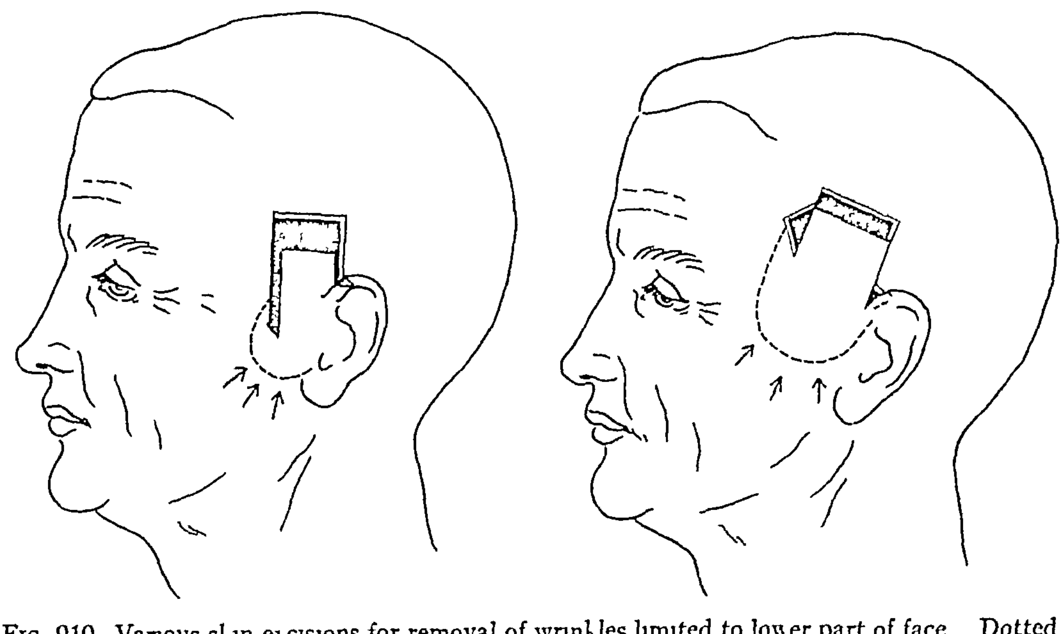


FIG 910 Various skin excisions for removal of wrinkles limited to lower part of face Dotted lines show amount of undermining Arrows indicate direction of pull (Volk and Winter)

Noel (87) constructed patterns of various shapes which may be sterilized and applied to the skin as an aid to excision These patterns are impracticable, however, as no two cases require sections of exactly the same size and form (fig 909)

Procedures designed for the removal of wrinkles limited to the lower part of the face, are shown in Figure 910

Nasolabial Folds

Nasolabial folds can be eradicated by the following procedure (fig 911), provided the grooves are not pronounced and the connective tissue fibers are not ruptured An incision 1 cm long is made along the alar groove. A pair of blunt scissors is introduced into this opening and the connective tissue adhesions are separated down to the angle of the mouth The line of the wrinkle is then elevated by a row of interrupted silk sutures passed externally through the unbroken skin along the base of the fold The small wound at the alar groove is closed. The sutures are removed in 24 to 36 hours The residual scar will be inconspicuous, being hidden in a natural fold

In severe cases where the connective tissue bands are broken, the same method may be employed as for the building out of a depressed scar Through the incision described above, the skin overlying the fold is elevated from the subjacent tissues, so

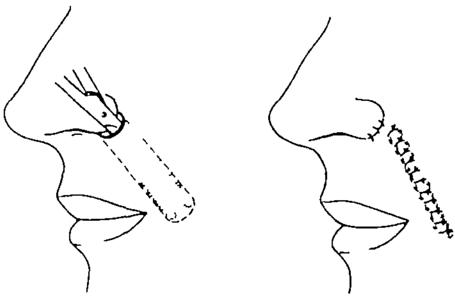


Fig 911 Eradication of nasolabial folds *a* adhesions along floor of groove separated with blunt scissors introduced through incision along alar groove. *b* line of wrinkle elevated by row of interrupted silk sutures passed along base of fold. Sutures removed in 24 hours

as to form a pocket for the reception of a graft. A piece of fascia lata is removed with the aid of a stripper and cut into sections about 1 cm. square. Through a cannula these transplants are introduced one by one into the previously prepared bed until the depression is leveled off The original wound is then closed with 1 or 2 horsehair sutures and a pressure dressing applied.

A more speedy and radical method is to excise the band of broken connective tissue in the same manner as one would excise a depressed scar, and approximate the wound margins with interrupted sutures of horsehair or a subcuticular suture of fine silk. As the incision lies in a natural shadow, the residual cicatrix will be barely perceptible

Hollow Cheeks

Hollow cheeks are due to the absorption of the buccal pad of fat and their correction is accomplished by the implantation of a fat-and fascia graft. An incision is made along the natural fold in front of the auricle. The tissues are undermined as

far as the hollow, and a bed is prepared A graft of fat and fascia is then procured from the abdomen, buttocks, or thigh and introduced into the prepared area (fig 912) As the greater part of the fatty tissue will be absorbed, it is well to overcorrect the defect to allow for this loss

A more suitable graft for the repair of such defects is one composed of de-epithelized skin (dermal graft) The material is elastic, resists absorption, and is easily invaded by the capillaries of adjacent tissues (35) According to Uihlein (114), "Schneider [106] found that cutis, like the other tissues which tend to regenerate most satisfactorily, contains no reduced glutathione He selected reduced glutathione to exemplify a product of tissue oxidation and reduction He analyzed the reduced glutathione content of various tissues to determine the role played by this substance in the ability of tissue transplants to grow He found also that tissues which do contain this reduced substance regenerated poorly when transplanted, according to the amount found in them "

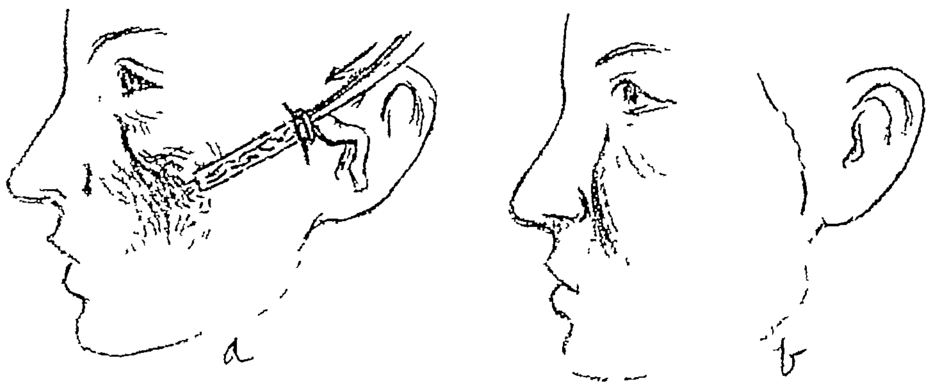


Fig 912 Building out of hollow cheeks with graft a, bed prepared through preauricular incision Graft of fat and fascia or de-epithelized skin passed through cannula b, wound closed with subcuticular suture

Neck Wrinkles

Horizontal wrinkles encircling the neck occur at an early age and produce no deformity Vertical wrinkles, however, due to fibrosis of the platysma muscle in consequence of advancing age, stand out as fibrous cords, especially when the head is turned, and impart a "stringiness" to the neck

Noel (87) corrects anterior neck wrinkles by removing a vertical spindle-shaped segment of skin from the back of the neck, and then undermining the tissues and approximating the edges of the wound (fig 913). While this procedure effaces the wrinkles temporarily, it leaves an ugly scar in the posterior neck region Kromayer excises a spindle-shaped section of skin along the posterior border of the sternocleidomastoid muscle, but this also creates a visible cicatrix

A more satisfactory procedure is the following (fig 898). An incision is begun below the lobule of the ear and is carried into the occipital scalp for a distance of 10 to 15 cm The lower lip of the incision is undermined, and the fibrous attachments between the platysma muscle and the skin are sectioned The mobilized flap is then drawn upward and backward until the wrinkles disappear The redundant skin is excised in the form of a triangle, with its base toward the ear. The flap is fixed subcuta-

neously to the mastoid aponeurosis, and the margins of the skin wound are approximated

In obese individuals a roll of fat may form as a transverse fold across the back of the neck Joseph (60) corrected this condition as follows A horizontal incision is made along the hair line on the back of the neck. The lower lip of the incision is

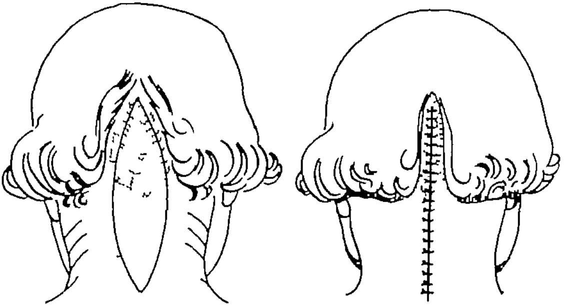


Fig 913. Noel operation for effacement of neck wrinkles *a*, vertical spindle-shaped segment of skin removed from back of neck. *b* margins of wound undermined and united.

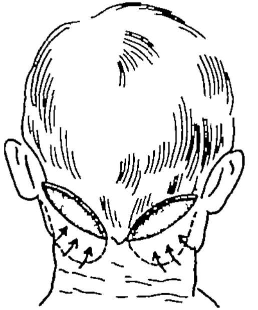


Fig. 914 Effacement of posterior neck wrinkles. Two semilunar segments excised from back of neck. Dotted lines indicate amount of undermining Excess fat, if present, removed. Redundant skin excised. Wound margins approximated. (Volk and Winter)

undermined and the excess subcutaneous fat removed The redundant skin is then drawn up with hemostats and that which overlaps the original incision is excised Finally, the margins are accurately sutured and a pressure bandage applied. Another plan designed for the removal of posterior neck wrinkles is shown in Figure 914

Double Chin

The double chin deformity is the result either of an irregular accumulation of fat below the mandible, or a fibrosis of the mandibulohyoid muscles which shortens the neck and makes the skin relatively excessive, so that it hangs in folds beneath the

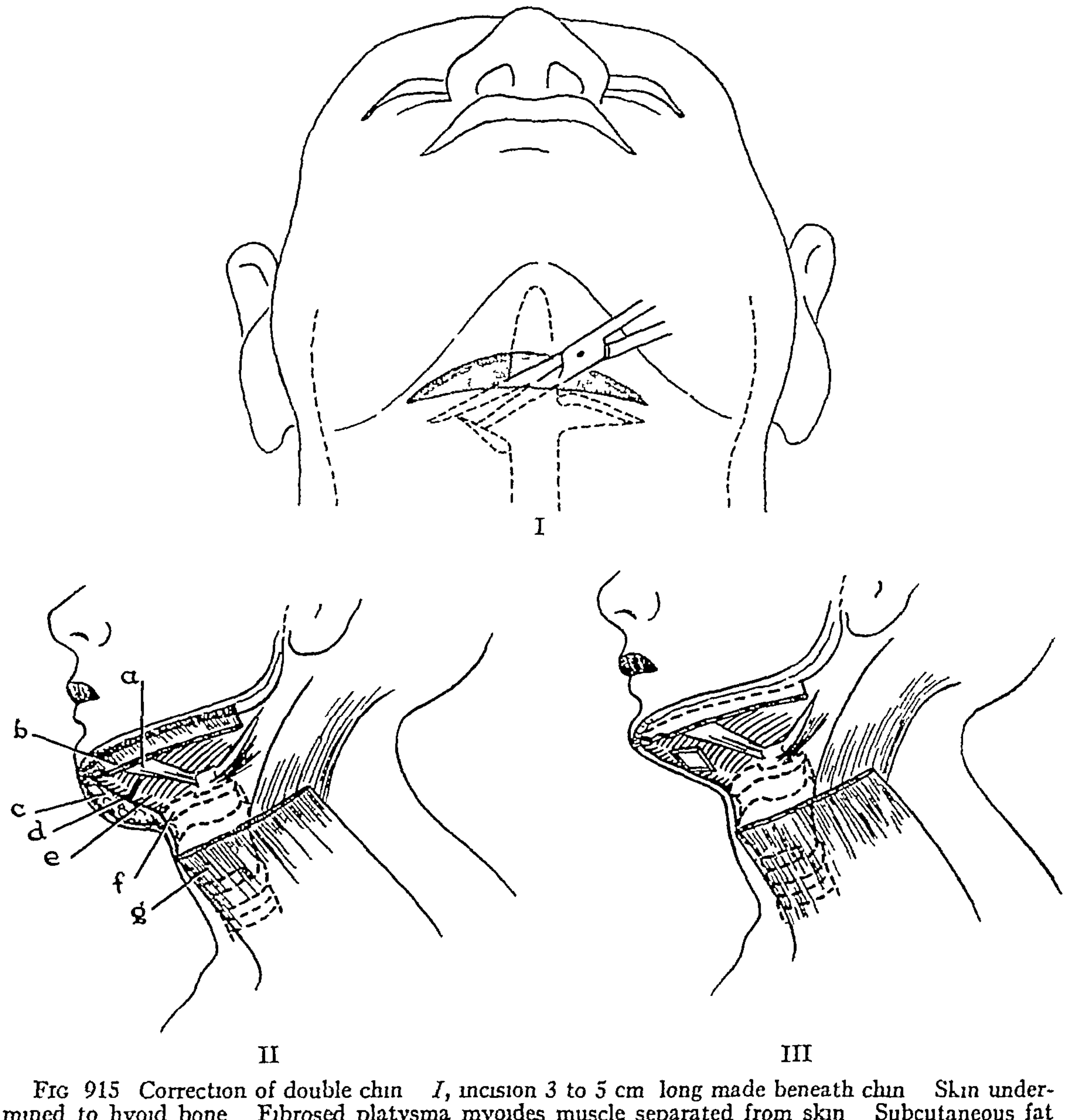


Fig 915 Correction of double chin *I*, incision 3 to 5 cm long made beneath chin Skin undermined to hyoid bone Fibrosed platysma myoides muscle separated from skin Subcutaneous fat resected Scissors shown making transverse incision through center of mylohyoid muscle *II*, diagram, showing relation of incision to surrounding structures *a*, anterior belly of digastric, *b*, platysma, *c*, subcutaneous fat, *d*, incision, *e*, mylohyoid muscle, *f*, hyoid bone, *g*, larynx. *III*, transverse incision sutured vertically

jaw Obviously when the two conditions occur simultaneously, as is frequently the case in advancing age, the deformity is especially marked

Joseph (60) and Passot (92) advised the removal of an elliptic section of skin and subcutaneous fat over the affected area The results of this procedure are too transitory to justify the operation Furthermore, it is impossible to approximate the margins

of the wound without buckling and in addition, the resultant ugly scar has a strong tendency to undergo keloidal degeneration

For a satisfactory correction of the condition, each of the following steps must be carried out (1) Removal of the superfluous fat (2) lengthening of the mylohyoid muscle (3) reconstruction of the submandibular region and (4) excision of the re-

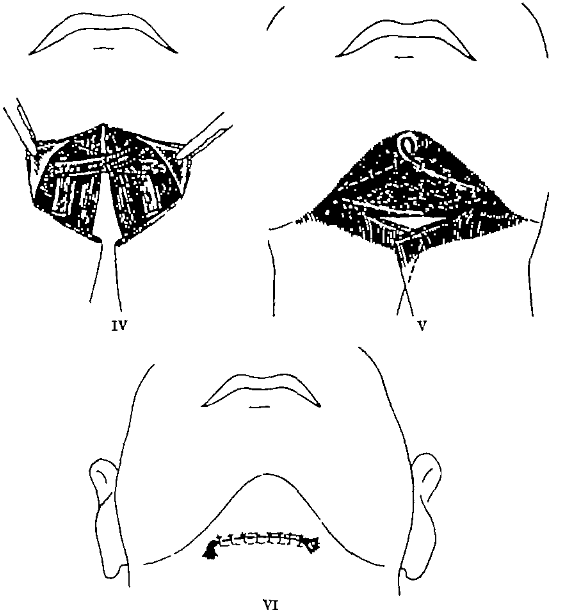


FIG. 916 Correction of double chin (cont.) *IV* reconstruction of mandibular floor· muscle flaps pedicled above cut from mylohyoid, crossed, and sutured to muscle on opposite side. *V*, platysma muscle previously loosened from skin imbricated across midline and sutured in place. *VI* skin wound closed. Several strands of suture material inserted into angles of wound for purpose of drainage and removed in 24 hours

dundant skin An incision 3 to 5 cm long is made in the natural crease beneath the chin Through this opening the skin is undermined as far as the hyoid bone and the fibrosed platysma myoides muscle separated from it, in order that the "stringiness" resulting from its attachment may be eliminated. The superfluous subcutaneous fat is removed. A transverse incision is made through the center of the mylohyoid muscle, and the wound margins, separated by means of 2 hooked retractors, are

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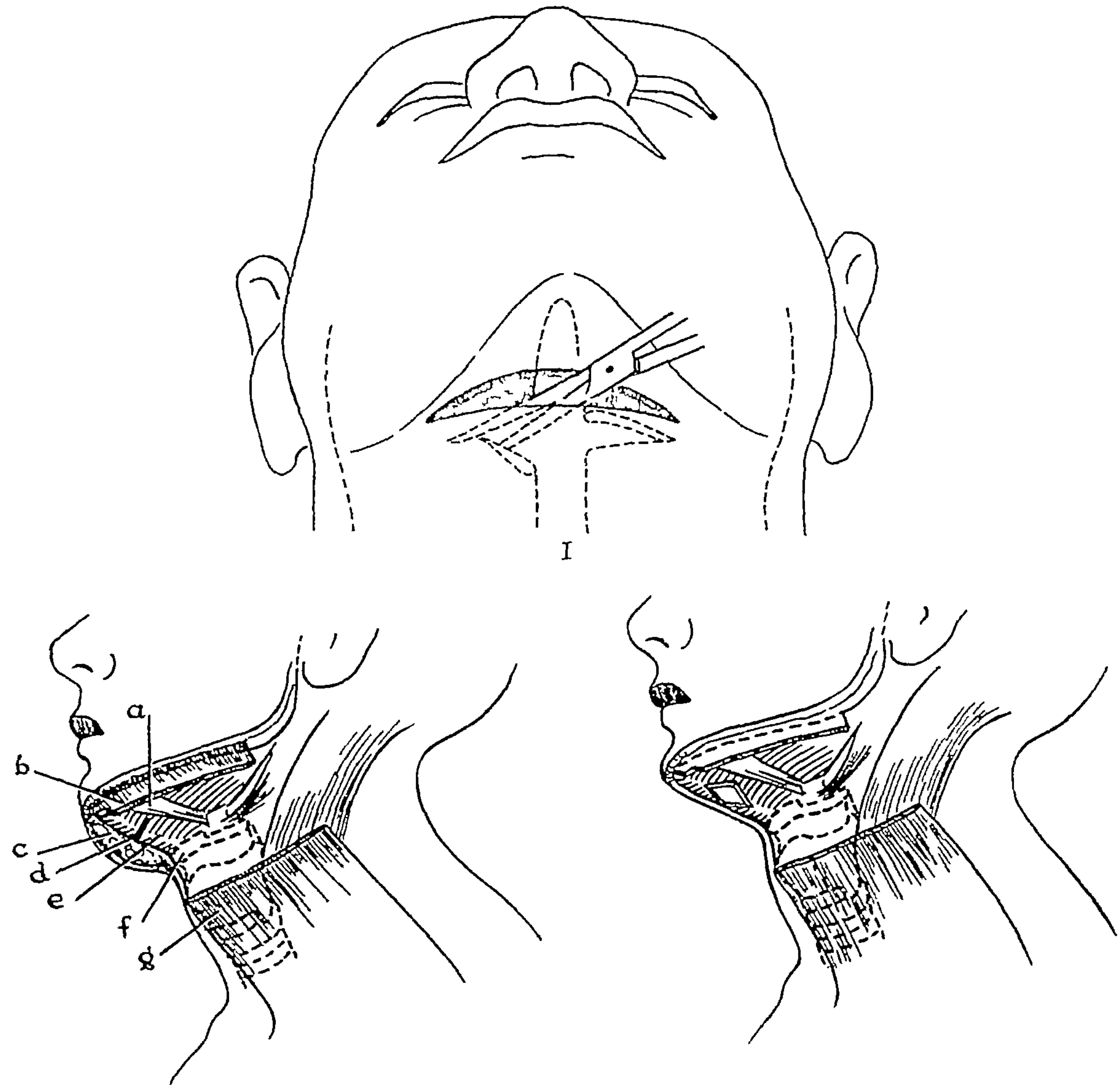

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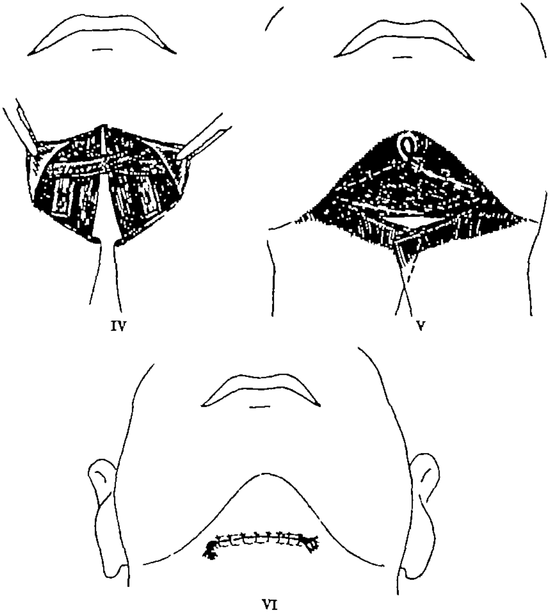

FIG. 916. Correction of double chin (cont.) *IV* reconstruction of mandibular floor muscle flaps pedicled above cut from mylohyoid, crossed, and sutured to muscle on opposite side. *V* platysma muscle previously loosened from skin imbricated across midline and sutured in place. *VI* skin wound closed. Several strands of suture material inserted into angles of wound for purpose of drainage and removed in 24 hours

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sutured vertically, the muscle thus being lengthened at the expense of its width (fig 915) The floor of the mandible is reconstructed in a manner similar to the operation for umbilical hernia Two muscle flaps cut from the mylohyoid and with their pedicles above are crossed and sutured to the muscle on the opposite side, the platysma fibers previously separated from the skin are imbricated across the midline and secured with a few silk sutures (fig 916) The loosened skin is now drawn over the underlying muscles in such a way that the chin assumes a normal contour, and is tacked down with a few subcutaneous sutures The margins of the skin wound beneath the mandible are then approximated, and several strands of twisted catgut are inserted into each angle for purposes of drainage The redundant skin is excised through retro-auricular incisions as in the operation for the eradication of anterior neck wrinkles (p 1364) In no event should the excess skin be taken from the front of the neck, as an ugly buckled scar with a tendency to keloid formation will form in spite of all precautions Finally, a firm bandage incorporating a marine sponge is applied, as a precaution against oozing and to obliterate dead spaces The drains are removed in 24 hours and the skin sutures below the mandible on the second or third day Those in the retro-auricular region may be left in place for 5 or 6 days

SCARS

Some degree of scarring is an inevitable concomitant of all wound healing, its extent being in direct proportion to the amount of tissue lost and to the rapidity with which healing takes place Histologically, scars are composed of a dense mass of connective tissue covered with a thin layer of epithelium devoid of papillae Lymphatics, nerves, hair follicles, and cutaneous glands are absent In the early stages blood vessels and cells are abundant, the scar appearing as a pink elevated mass, but as the connective tissue fibrils contract, the cells flatten out and decrease in number, the blood vessels become constricted, and as a result the cicatrix appears flat and avascular Scars may be classified in relation to the surface, as elevated, flat, or depressed, in regard to texture, as soft and pliable, hard and fibrous, smooth, or warty, in respect to their clinical course, as inflamed, painful, ulcerated, contracted, adherent, unstable, or malignant, and in regard to shape, as linear, stellate, webbed, etc Extensive scars may cause great deformity and serious impairment of function as a result of the atrophy and distortion of bones, muscles, tendons, nerves, and blood vessels, and ankylosis of joints which they occasion

Since scar tissue formation is directly proportional to the rapidity with which repair takes place, the institution of measures designed to hasten wound healing will do much to minimize the extent of the scar and the deformity consequent upon its contraction (p 263) Due attention must be given to constitutional conditions, such as tuberculosis, syphilis, diabetes, and impoverished blood states The part should be allowed to heal in such a position as will permit of the best ultimate function For example, if the wound is in the axillary region, the most favorable position as regards function will be obtained by fixing the arm in abduction at an angle of about 45 degrees, with the elbow in front of the axillary line, if the wound is on the anterior surface of the neck, the head is immobilized in extension, if it is on the front of the elbow or on the back of the knee, the limb is likewise put up in extension, if on the front of the wrist, the hand is maintained in dorsiflexion; if on the front of the ankle, the foot is plantar-flexed, and if around the hip, the limb is extended and abducted.

Removal of Scars

There are many plans which may be adopted in the management of scars, and the choice will depend upon the size, location, depth, and shape of the lesion and the condition of the surrounding skin In any case removal should not be undertaken until several months after the time of injury, otherwise, a quiescent deep-seated infection may be reactivated During this period appropriate measures should be taken for the improvement of the patient s general health, and the scar softened by massage and baking, and, in the case of flexion deformities, by gradual extension of the part Such treatment not only improves the nutrition of the area, but frequently obviates the need for an operation previously deemed unavoidable. Prior to the removal of

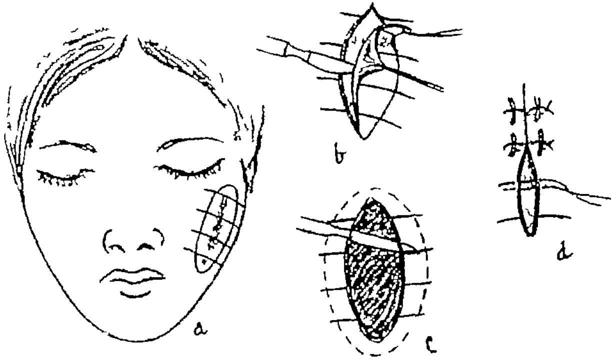


FIG 917 Removal of scar *a*, scar outlined in methylene blue, and parallel lines 1.5 cm. apart marked out, to serve as landmarks for placing sutures. *b* scar tissue excised. *c*, margins undermined, to permit of tensionless closure. *d* margins approximated with on-end mattress-sutures placed in accordance with previously marked-out lines Morsels of suture material inserted beneath suture loops.

the scar, residual infection should be tested for by manipulation of the part. Should a local reaction take place, excision should be deferred.

In most instances anesthesia is best obtained by a regional block (p 416) This is superior to infiltration as the latter method distorts the parts, lowers their vitality, and renders accurate closure difficult. In cases where the scar is to be used as a flap, it is advisable to resort to general anesthesia, in order to eliminate the danger of further lowering the resistance of the part by the direct introduction of the anesthetizing agent.

The simplest procedure for the removal of a scar is excision followed by direct approximation of the wound margins. This method is applicable in cases where the cicatrix is narrow and the surrounding skin sufficiently lax to permit of approximation without tension on the suture line or distortion of the circumjacent parts. The technic is as follows The operative site is prepared and draped in the usual manner The section to be excised is outlined with methylene blue in a hypodermic syringe,

the needle acting as a pen The pattern is made to follow the normal skin tension lines and is so designed as to allow easy closure At exactly corresponding sites along both sides of the section thus traced, a series of lines 1 5 cm apart are marked out with the point of the needle to serve as landmarks for the placing of the sutures (fig 917) Without such a guide the distortion of the tissues occasioned by the local anesthetic is apt to create difficulty in bringing the margins into their proper relationships

The parts are then anesthetized, and the outlined area is cleanly incised down to normal tissue by a single stroke of the knife Repeated cuts are to be avoided, as the frayed edges thus produced interfere with healing It will frequently be found that the incision on one side of the cicatrix can be made with ease, while that on the opposite side offers difficulty, due to the loss of support resulting from the primary incision If the scar is linear, this problem can be solved by the use of an adjustable double knife, as illustrated in Figure 13 With this instrument both cuts are made simultaneously, the outline being completed by joining the ends of the parallel incisions in such a manner as to form an elongated oval Irrespective of the extent of cicatricial tissue, it should be removed completely whenever possible, since only in this way can the adjacent tissues be "untangled" and readjusted to assume their original relationships After excision of the scar, the skin margins are undercut just sufficiently to insure against tension, and the wound is closed with the least possible trauma Fine dural hooks or cotton-covered forceps should be employed in the handling of the tissues

To obliterate dead spaces and reduce tension on the skin margins, closure is begun by coapting the deeper parts of the wound in layers, the finest silk or #0000 plain catgut mounted on a curved eyeless needle being used for the purpose It is especially important that the margins of the superficial layer of the deep fascia be approximated in order that the wound may be given adequate support and the scar prevented from spreading The points previously marked out on the skin margins are then united with on-end mattress-sutures of the finest waxed silk on an eyeless needle or with horsehair If the skin is thick, an intradermic suture may be used, provided the wound does not exceed 4 to 5 cm in length, for longer incisions a double subcuticular suture is recommended (p 77) If the deep structures have been properly coapted, the line of incision will at first bulge, but as healing and contraction take place, the ridge will disappear

The suture line is covered with 1 or 2 layers of xeroform gauze, overlaid with several layers of plain gauze Above this is placed a pressure dressing incorporating a moistened sterile sea sponge Finally, the part is immobilized by means of an appropriately applied bandage, and the dressing is left undisturbed until the time for removal of the sutures An ice bag may be applied to advantage for the first 48 hours, to limit the associated inflammatory reaction As no tension was exerted in the closure, the skin sutures, which were used merely to hold the skin in easy approximation, may be removed as early as 48 hours following their introduction Subcuticular sutures may be safely left in place for 5 to 7 days

If after excision of the scar direct approximation of the wound margins would entail undue tension on the suture line, the wound can frequently be closed by advancement or rotation of the surrounding tissues (pp 233–243) The methods of Blaskovics

and Imre, the basic principle of which is illustrated in Figure 918, can frequently be employed to advantage Czukrász (23) description of the procedures can hardly be improved upon. Figure 144-(1) illustrates the closure of a triangular defect according to the method of Blaskovics. 'ABC represents missing skin To create a flap we make an arc like incision, CDE, starting at C, which should be 4 or 5 times as long as AC We make the cut so that the line DE shall extend beyond the line BD, which is parallel to AC It is not advisable to make a shorter arc because then we could obtain a sufficient covering only by stretching more or less the basis of the flap, which is undesirable owing to the nutritive circumstances The longer the cut, the better the flap can be lifted in the CA direction

"The elevation of the flap at point D always depends on the arc-cut, as is to be seen in Figure 144-(2) If we draw the arc with the radius BC, when we bring the Burow triangle together, G falls on F, and the distance BG and BF are equal, and

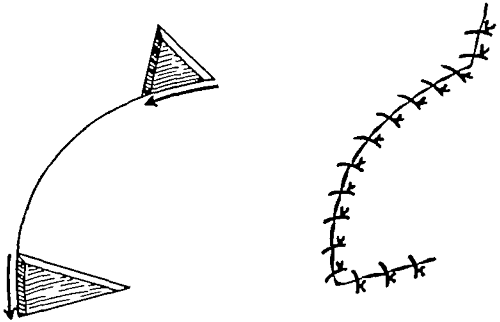


FIG. 918. Diagram illustrating principle of skin closure by advancement and rotation of contiguous tissues, according to methods of Blaskovics and Imre. (See Figure 144)

then there will not be any elevation in the basis of the flap If the radius is CE, the elevation will appear at KL the longer the radius, that is to say, the steeper the cut is made, the more satisfactorily the elevation will fall in the perpendicular line BFHJ"

For the closure of oval and crescent shaped defects the arclike cut starts a little lower than the beginning of the defect (fig 144-(3)), "but the little unevenness which so arises at C can be corrected easily in the sewing up of the wound. Figure 144-(3) shows the possibility of covering the defect. We may take the oval defect as if triangular, and start the cut at the point of the triangle of the flap ABC, but this can be removed easily, as is done in DEF

Figure 144-(6) illustrates the method of Imre "Imre gives an essentially larger curve to the arc, that is to say, he makes the cut with a smaller radius than Blaskovics does. The length of the radius according to Blaskovics, plays a very important role in the results obtained There is also a difference in the technique of undermining the flap

Blaskovics prepares underneath the flap and under the surrounding skin so that the distant part of the Burow triangle can move freely In contrast to this, Imre mobilizes the flap, and the secondary defect which is thus made can be covered when the lower edge of the wound and the anterior part of the Burow triangle is undermined In this lies the essential difference of the two methods Imre transposes, while Blaskovics slides the flap over the prepared ground In reality the two methods approach each other in so far as the same missing skin can be replaced with flaps of different curvature and length "

If the loss is too great to permit of closure by the methods already described, the raw area will require resurfacing. Should the defect be superficial and the bed capable of furnishing adequate nutrition—as, for example, in the case of a burn scar—a full thickness graft is employed (p 144) But if the loss is deep, or the base poorly nourished—as in the case of scars resulting from infection or those situated over bones, tendons, or joints—a flap must be resorted to (p 204)

Radiotherapy

Newly formed cicatricial tissue, like other embryonic tissue, is radiosensitive Therefore, x-ray or radium therapy will effectually limit its production and should be administered as soon as healing has taken place If *Roentgen ray* is used, the best effects are obtained with ½ to ¾ of an erythema dose of low voltage and high filtration Four applications are given at 14-day intervals, and after a month's rest the treatment is repeated Grier (51) reports good results with unfiltered Roentgen ray He cautions against an amount exceeding 90 per cent of an erythema dose and advises an interval of 6 to 8 weeks between treatments Following the removal of scars with a keloidal tendency, Webster (124) protects the surface skin by placing an apertured lead shield over the suture line, and uses a 3 mm aluminum filter at a distance of 25 cm , with a minimum voltage of 125 to 135 kilovolts for a duration of 5 minutes, which is equivalent to 20 milliampere minutes He states that the average case requires 10 to 12 such treatments and that they should be begun as soon as epithelization has taken place Hodges (55) obtained good results with 250 to 300 r unfiltered rays, 80 to 90 kilovolts being administered every 4 to 6 weeks

If *radium* is used, it is best administered in the form of a surface application immediately following closure The exact position of the suture line is marked out on the dressing, and a radium tube containing 10 mg of radium element is placed over this line The filter is 1 5 mm of platinum If the scar is long, 2 or more tubes may be laid end-to-end across the dressing

Any irregularities remaining after irradiation therapy may be leveled off by cauterization with trichloracetic acid Ahlswede (2) uses a solution composed of hydrochloric and carbolic acid each 1 part, pepsin 10 parts, and enough distilled water to make 200 parts

Attempts to eliminate scar tissue by the injection of thiosinamin and the internal administration of glandular extracts, such as thyroid, have proven ineffectual In the case of superficial scars scarification has been advocated (42) The technic is as follows After the skin has been cleansed with 90 per cent alcohol, it is stretched between the fingers Then with a vaccination knife or sharp scalpel held pencil-fashion a series of close parallel incisions is made through the upper layers of the skin by quick

downward movements. A crust soon forms which falls off spontaneously in 4 or 5 days. The utility of this method is questionable.

Flat Scars

Flat scars vary considerably in size, have a parchmentlike consistency, are of a coppery red color, and usually follow burns. If they are extensive, stable, and so located as to be inconspicuous, they are best left alone, since their excision would necessitate resurfacing by means of a graft or flap which would be but little less noticeable than the original cicatrix. If they are small and conspicuous, they may be completely excised and the wound margins accurately approximated. In case the scar is too large to permit of direct subsequent approximation of the margins, it can frequently be removed in successive stages by *gradual partial excision* and with careful planning the residuary linear cicatrix can often be concealed in a natural fold. The method was first used by Morestin (80) (1915), who removed a mole from the face in 12 stages extending over a period of 4 months. Later he resected a scar of the neck and breast in 18 stages over a period of 11 months and claimed that the result was better than if a graft or flap had been used. Sistrunk (108) (1926) described a similar procedure of which the technic is as follows (fig 919). In the first stage a section of the scar of such size and shape as to permit of easy approximation of the margins is excised. The wound is sutured either with or without undercutting, the suture line remaining within the scarred area. After an interval of several months, when the surrounding skin will have stretched and the scar has been softened by massage, a similar section is removed including the suture line. The process is repeated until the entire cicatrix has been eliminated. Even though the dimensions of the scar may prohibit its complete removal by this method, nevertheless the procedure will often be found advantageous to reduce the size of the scar and thus permit of the use of a smaller graft or flap.

As an alternative to gradual partial excision, recourse may be had to the use of a *sliding flap*, as suggested by Imre (59), Blaskovics, and Esser (37). The details of the method are described on page 1371.

As a last resort, the entire scar may be *excised* and replaced with a full thickness graft or flap. If the defect is on the face, where it is important that the donor skin match its surroundings, the graft is best taken from the skin of the eyelids or from the retro-auricular region, provided these areas can furnish sufficient material to cover the raw surface.

Depressed Scars

Following the removal of small depressed scars, Esser (37) introduces the suture in such a manner that it will incorporate a small margin of the skin together with a deep bite of the subcuticular tissue on each side of the wound. Thus, when the suture is tied, there results a slight elevation along the suture line. As healing and contraction take place, this ridge gradually sinks to a normal level. Larger depressions can often be filled out by undercutting the fat and fascia on either side of the wound in the form of a flap and rotating it on a pedicle under the proposed line of suture (figs. 920–922). Poulard (96) uses the scar mass as a buttress and approximates

the healthy tissue over it, as follows (fig 923) The scar is circumscribed by an incision passing through the adjacent healthy skin and underlying fat The epidermal cover of the scar is then removed, but the main mass of cicatricial tissue is left in place The wound margins are undermined in the plane between the fat and fascia, and the edges are brought together over the remaining scar mass and sutured, the thick layer of healthy tissue above the scar sufficing to overcome the depression

If the hollow is too deep to be filled out by any of the above methods, it can be built up with a dermal or a fat-and-fascia graft (fig 924)

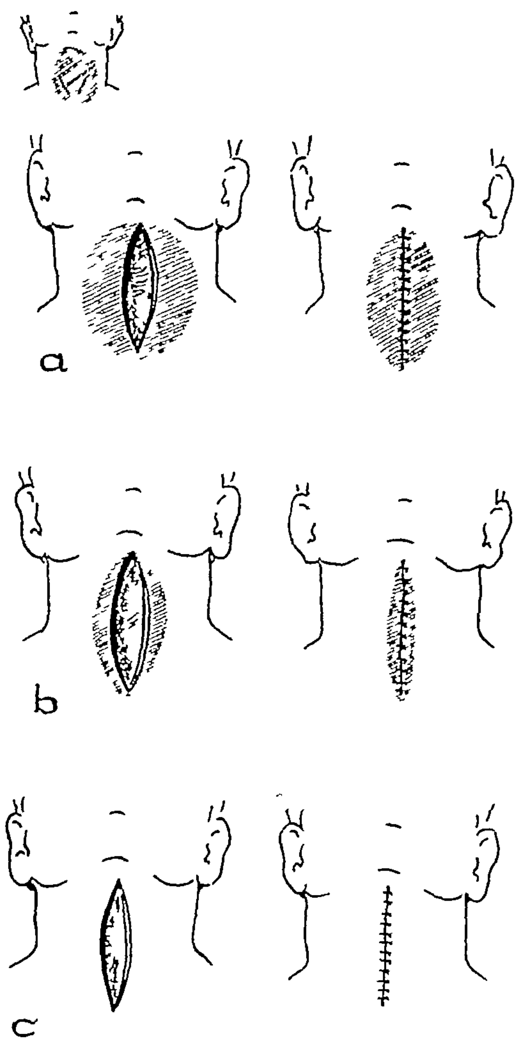


Fig 919 Removal of scar by gradual partial excision *a*, section removed from central portion of scar Wound closed Insert shows extent of original scar *b*, after several months, another section incorporating suture line similarly excised *c*, at third stage, balance of scar removed Wound closed

Keloidal Scars

A keloidal scar results from a hypertrophy of the collagen fibers of the corium It appears as one or more smooth, dusky red, elevated patches with clawlike projections reaching into the surrounding skin The condition was recognized in ancient times, as is evidenced by its mention in the Smith papyrus (1500 B C), but Retz (1790) and Alibert (4) (1806) must be credited with its description as a pathologic entity

Keloids are encountered most frequently in young, dark-skinned individuals be-

tween 20 and 30 years of age It is estimated that negroes are affected 6 times as often as members of the white race. A hereditary susceptibility has been noted by Hutchinson (58) and others. These scars are usually the result of burns and of wounds which have been closed under tension or have undergone infection Why the connective tissue should persist in proliferating after the continuity of the wound has been re-established is not known Crocker (22) suggests a bacterial origin, and in

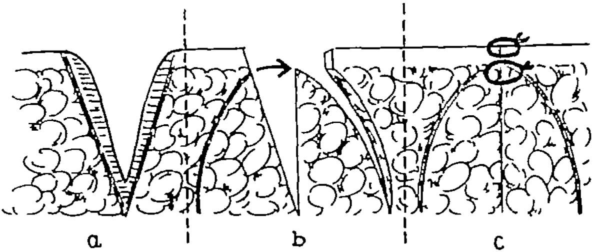


FIG. 920 Esser's method for elevation of depressed scar *a* scar tissue excised along solid lines *b* fat-and-fascia flaps raised from either side of wound *c* flaps approximated in midline under proposed suture line. Overlying skin sutured.

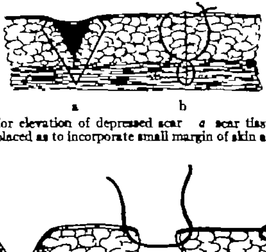


FIG. 921 Blair's method for elevation of depressed scar *a* scar tissue excised along solid line *b*, wound closed. Sutures so placed as to incorporate small margin of skin and deep bite of subcuticular tissue.

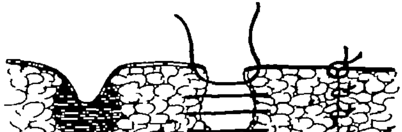


FIG. 922 Removal of depressed scar by excision followed by approximation of wound in layers.

proof of his contention he points out the fact that keloids are most common following suppurating wounds Da Costa (24) believes that they have some relation to tuberculosis, as they are prone to affect persons with tuberculous glands He ventures the supposition that the irritating agent is the toxin of the tubercle bacillus rather than the organism itself in view of the fact that the bacillus cannot be isolated from the growth The condition has also been attributed to endocrine dysfunction, especially of the thyroid gland.

Keloids originate in the deeper part of the corium and in the walls of the blood vessels, in contradistinction to hypertrophied scars, in which the papillary bodies are the structures first to be involved According to Warren (121), the first change occasioned by the formation of these growths is an infiltration of "round cells" into the adventitia of the arterioles of the corium In the early stages of their development keloids show large, sharply defined, homogeneous, collagenous fibers strictly limited to the corium and running parallel to the skin surface and to the long axis of the scar Between these fibers and around the contiguous blood vessels are scattered a few oval-shaped connective tissue cells with relatively large nuclei showing mitotic figures It is believed that these cells account for recurrences of the growth following removal Eventually, the fibers contract, compressing and displacing the surrounding skin glands and hair follicles

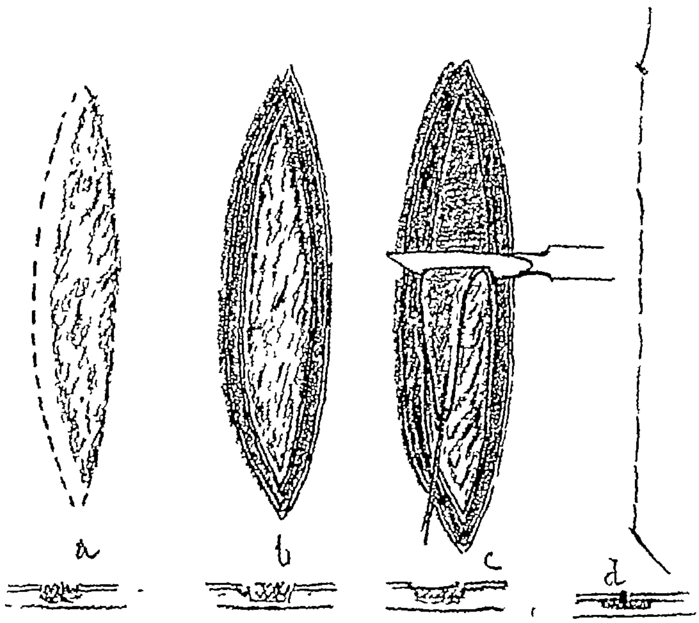


FIG 923 Elevation of depressed scar by use of scar mass as buttress *a*, scar outlined by incision, as indicated by dotted line *b*, shows retraction of skin margins following incision *c*, epidermal layer sliced from scar *d*, wound margins undermined and approximated over scar buttress with subcuticular suture (Poulard)

The scar appears at first as a deeply seated, firm, soft rose or wine-colored, dome-shaped nodule, pliable on manipulation and somewhat sensitive to the touch and to heat When fully formed, it is smooth, oval, or elongated, and appears as a button-like mass or as an elevated cord with lateral unguiculate projections extending into the surrounding tissues These projections are arranged in striae, linear bands, or ridges, or in various combinations of these figures The overlying skin is tightly stretched, smooth, and hairless, and through the thin epithelial covering telangiectatic vessels can often be seen In size keloids range from a pinhead to a dinner plate and in number from one to a score or more Aside from causing disfigurement, they entail little inconvenience, although occasionally patients complain of itching or burning sensations and of hypersensitivity in the affected area The course of the lesion is toward the production of a medium-sized tumor, which after reaching certain dimensions tends to remain stationary and to persist throughout the life of the individual Spontaneous regression, however, has been known to occur Only in rare instances do these growths undergo ulceration or malignant changes

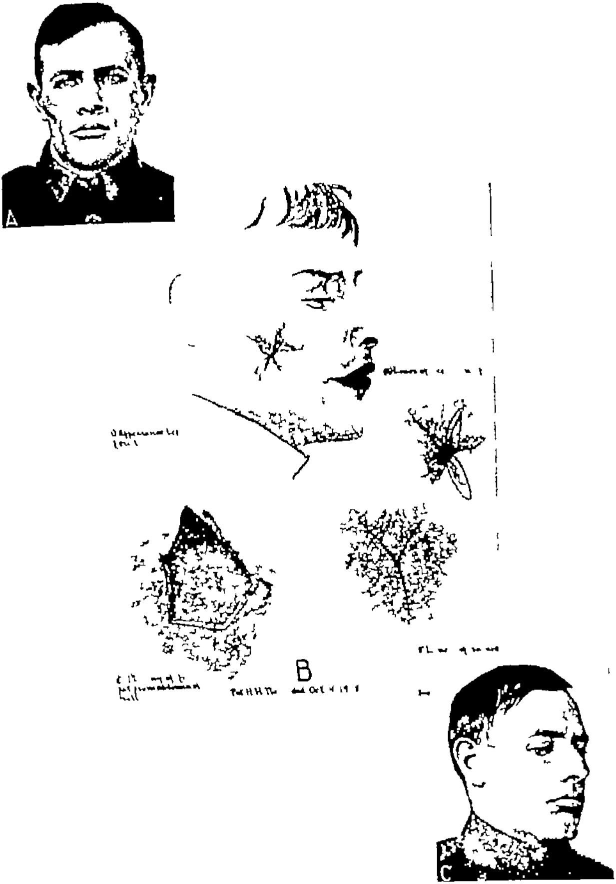


FIG. 924. Building out of depressed scar by fat-and-fascia graft taken from abdomen. *A* depressed cheek scar adherent to bone. *B* stages of operation *C* final result. (Medical Dept. U. S. Army, Vol. XI)

Treatment. Surgical ingenuity has not as yet evolved an entirely satisfactory technic for the eradication of keloids, although many methods have been employed with varying degrees of success

Excision alone is rarely effective, since the trauma of operation will produce the same stimulus as did the original injury, but excision supplemented by irradiation frequently brings about a permanent eradication of the growth In the dissection of the scar it is imperative that all prolongations be removed and that this be accomplished with a minimum of trauma, otherwise, there may be a recurrence more extensive than the original lesion The incision is made well outside the limits of the keloid and along the lines of Langer The edges are trimmed to form simple geometric figures, in order to facilitate approximation, as any undue tension on the wound margins will favor a return of the condition The wound is closed by means of a few interrupted on-end mattress-sutures of horsehair Intradermal sutures are to be eschewed because of the irritation they occasion If approximation cannot be easily obtained without tension, the area should be skin-grafted Ordinarily, keloids do not develop in the transplant itself, although they are prone to form at the junction of the graft and the host As soon as healing is complete, irradiation therapy should be instituted without delay, since, as has been previously stated, connective tissue cells are most radiosensitive in the early stages of their growth.

Hypertrophied Scars

Hypertrophied scars are usually the result of slow healing Microscopically, they consist of small collagen fibrils in which the hyperplastic connective tissue does not pass beyond the limits of the primary cicatrix In their early stages they are soft rose or wine-colored, pliable on manipulation, and somewhat sensitive to the touch and to heat Later they become fibrous, pale in color, and present the appearance of an elevated cord several millimeters thick, stretched over the surface of the skin Attempts have been made to differentiate these scars from the keloidal type discussed above, but for practical purposes such a distinction is pointless, inasmuch as the pathologic changes in both cases are essentially the same Their treatment is similar to that prescribed for keloids, and as they have less tendency to recur, the results are more satisfactory

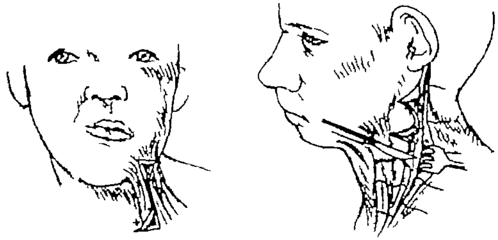
Contracted Scars

Contracted scars usually develop as the result of extensive burns and may be superficial or deep Their importance lies chiefly in the disturbance of function which they occasion, especially when they are located over flexor surfaces of joints In the hand the fibrous tissue may fuse the fingers into an unsightly useless mass, in the neck the chin may be drawn down and fixed to the sternum, and the lower lip everted If muscles are involved, they become shortened, and the resultant bowstring effect limits motion If the capsular ligament is affected, subluxations are likely to ensue Moreover, nerves may become incorporated in the scar tissue and lead to pain and paralysis Finally, in the case of growing children, the cicatrix, if extensive, may interfere with the growth of surrounding structures

In mild cases, where the scar is superficial and not too widely spread, gradual stretch-

ing combined with massage and x ray therapy is often sufficient to overcome the disfigurement. In moderately severe cases several methods have been devised for the correction of the deformity without the introduction of new tissue Dupuytren and others suggested that the tension be relieved by incising the scar tissue and allowing the raw area to granulate with the part in an overcorrected position This method has little to recommend it, however as the subsequent contraction will cause a recurrence of the condition.

In the case of *webbed scars* which are pliable and carry enough nutrition to permit of their use as flaps, the tension may be broken and the cicatrix lengthened by a type of transposed flap known as the Z- or S-plastic (fig 925-a) For details of the technic, see page 242 Briefly, in the use of these flaps certain precautions are essential. In planning the operation care must be taken to utilize the best available tissue, the incision should be carried down to tissues having a good blood supply, the deep cicatrix should be excised to assure a minimum of tension on the flaps, and all angles rounded to guard against sloughing If the contraction is of long standing, several such opera



a b

Fig 925 Methods for release of contracted scar of neck. *a* Z-plastic. *b* Morestin's method. For details, see text.

tions may be required. As much improvement as possible is achieved at the first sitting, and several months later when the tissues have stretched, the procedure is repeated in the same area. Because of the poor blood supply, necrosis of the flaps is likely to take place, but should this happen, nothing is lost.

Morestin (80) modified the Z-plastic operation in the following manner (fig 925-b) A longitudinal incision is made over the most prominent part of the scar The margins of the wound are undermined, and several small lateral incisions are made on both sides at right angles to the original incision, and placed in such a way that they appear midway between two similar incisions on the opposite side When the part is placed in an overcorrected position the tension on the contracted skin causes V-shaped spaces to be formed along the margins. The intervening flaps are dovetailed into the notches of the corresponding side and the wound is sutured.

Occasionally function can be restored only after excision of the scar, overcorrection of the part, and resurfacing of the raw area with a full thickness graft or flap In such cases, before the removal of the cicatrix, the position of the part is corrected as far as possible by gradual traction and massage. The scar is then excised through

out its entire extent—a procedure which may entail extensive dissection, and the exposure of nerves, tendons, blood vessels, muscles, and joints Even after the cicatricial tissue has been completely resected, however, it may still be impossible to put the part in a functional position without resort to tendon lengthening (p 291) If in the process of extension the lumina of the blood vessels show a tendency to become flattened, rupture is imminent, and further stretching should be avoided The remaining raw surface is covered with a full thickness skin graft If nerves and tendons are exposed, the area is resurfaced with a thick flap

In the case of a superficial cicatrix it is frequently practicable to obtain relaxation by means of a tunnel graft, as described on page 153 Briefly, a tube of full thickness skin, raw surface out, is implanted beneath the scar, and after sufficient time has elapsed for it to "take" in its new position, the scar above the graft is incised in such a way that the tube of implanted skin forms the base of the incision

Unstable Scars

An unstable scar is one in which the epithelium is thin and the circulation poor They are most commonly observed following burns As they are prone to break down when subjected to slight trauma and are liable to infection, they should, as a general rule, be excised and the denuded area resurfaced with a graft or flap

If such a scar is so extensive that complete excision would be impracticable, Davis (27) advocates the use of relaxation incisions The contracted portion is put on stretch, and the most binding area of the scar is located and incised down to normal tissue The tight margins are loosened by means of radiating incisions placed at points of greatest tension If the scar is thick, a wedge-shaped slice of the deepest layer is removed from either side, so that the thin surface edges may be drawn downward and attached to the normal base The remaining raw areas are immediately covered with full thickness grafts, in order to prevent their subsequent contraction In the case of scars of long standing, however, the bed usually has such a poor blood supply that it is incapable of providing sufficient nourishment for a graft Under these circumstances either grafting should be postponed until granulations have formed, or the raw area should be covered with a flap

Pigmented Scars

Pigmented scars are caused by the grinding into the skin of powder granules, particles of oil, dirt, or pigment, which appear in the cicatrix as bluish marks. The treatment will depend upon the location, amount, and degree of pigmentation If isolated, the particles may be excised with a cataract knife and each little wound sutured Should the pigmentation be diffuse and superficial, the pigment layer is shaved off in a manner similar to the removal of a thin razor graft, and the area is allowed to heal If the granules are deeply embedded, the scar is excised and the wound closed either by direct approximation or with a skin graft

Adherent Scars

These scars are characterized by their adhesion to subjacent structures and are frequently painful, since any movement of the part causes them to be dragged upon.

If attached to muscle, the cicatrix tends to infold upon movement of the overlying part and may become cracked as a result of the friction. In such cases relief can be afforded by elevation of the scar and the interposition of a layer of fascia between the muscle and the skin If the scar is so situated that its complete removal is necessitated, the raw area is resurfaced with a flap, since it offers insufficient nutrition to assure the survival of a graft.

Wakeley (119) reports good results following the use of human oil A portion of the omentum removed from a person who has undergone an operation, is thoroughly washed until it has been freed from serum and blood It is then placed in a specimen jar half filled with distilled water and heated for ½ hour in an autoclave at a temperature of 120°C The free globules of fat on the surface of the water are removed with a sterile pipet and placed into 1-cc. ampules A part of the fat is innoculated into a broth culture to check its sterility Before use, the ampule is warmed in water at a temperature slightly above that of the body The neck of the container is then broken and the oil drawn up in a warmed 5 cc Record syringe After the scar tissue has been carefully cleansed, the needle of the syringe is inserted at a point along the margin and advanced in the plane lying just beneath the scar tissue, the oil being introduced as the instrument advances. Not more than 1 cc. is delivered at any one place, as the scar may give way Several different areas can be injected at one sitting Wakeley states that "about twenty four hours after the injection the site becomes somewhat red and hot, this condition persists for about twelve to twenty four hours and then gradually disappears Injections can be given at fortnightly intervals, and by degrees the adherent scar is made to float upon the underlying structure."

Painful Scars

Painful scars result from pressure upon adjacent nerves or from the incorporation of nerve filaments in the cicatrix. The treatment consists in freeing or sectioning of the nerve. If this fails to bring relief, the cicatricial tissue is excised and the wound margins either approximated or resurfaced with a graft or flap

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CHAPTER XX

CASTS AND PROSTHESES

CASTS

In the majority of reparative operations, especially those about the head, a cast of the defective part is of great assistance. These casts serve many purposes (1) They permit of a leisurely study in planning the line of incision, in determining the most desirable site for the pedicle of a flap, and in calculating the size of a graft. They are also of value in estimating the thickness of the tissue to be replaced. In the latter case the defect is built up on the cast in clay or wax to the proper contour The clay or wax is removed, invested in dental compound, and cast in metal in the same manner as a dentist would construct an inlay This model can be sterilized and used in the operating room as a guide in the cutting and shaping of the graft. (2) They are invaluable for recording the progress achieved in a many-staged operation and to serve as a guide to future procedures. (3) They form a convenient medium for teaching purposes. (4) Finally, they serve as a basis for the construction of prosthetic appliances

Paraphernalia The materials necessary for the construction of a cast include quick-setting dental plaster of Paris, a large rubber basin, a large spoon, an iron spatula, short rubber tubes, vaselin, castor oil, an eye-dropper, a rubber cap, cardboard, drapes.

Construction of Negative Mold

The patient is placed comfortably in the dorsal position, with the head in straight alinement with the body He is requested to lie quietly and to avoid facial movements and is told that the plaster will become warm during the setting process and that he is not to be alarmed, as it will cool directly The hair is protected by a rubber cap, and a sheet of heavy cardboard with an opening in the center just large enough to expose the part to be cast is fitted over the face. The eyelashes, eyebrows, and beard are anointed with a thin layer of vaselin, and a drop or two of sterile castor oil is instilled into each eye. Finally, two small soft rubber tubes or cardboard cylinders are inserted into the nostrils and packed around with bits of cotton, care being taken to avoid distortion of the natural form of the alae.

The material ordinarily used for the construction of the negative mold is plaster of Paris, although many operators prefer softened stent and water-soluble colloids. An example of the latter is marketed under the name of Negocoll.

Application of Plaster Into a large rubber basin are poured 1.5 liters of cold water, and to this 3 kilos of plaster of Paris are added gradually and stirred until the mixture has reached the consistency of thick cream. It is then applied to the face with a large spoon, beginning at the chin and working upward, in order to support the facial muscles and prevent their distortion by the weight of the plaster When the entire face has

been covered, successive layers are applied, until the mold has attained a thickness of 2 to 3 cm When it has hardened—a process which takes about 10 minutes—it is carefully lifted off with the hands by placing them under the cardboard frame and tilting the cast from above downward The patient is requested to keep the eyes closed until all particles of plaster have been removed from about the corners of the eyes The cast is set aside to dry out for one-half hour or longer Rough projections are then smoothed down with a metal scraper and sandpaper, and the nostrils are built out with soft plaster

If Negocoll is to be used, it is applied in accordance with the instructions given by the manufacturer. Briefly, it is melted in a double boiler, allowed to cool to body temperature, and applied to the part with a brush or with the fingers to a thickness of 2 to 3 cm If desired, the material may be reinforced with plaster, wire, or gauze Negocoll, although comparatively expensive, has the advantage that it can be used over and over again, duplicate casts can be made from the same negative, and, due to the elasticity of the material, its removal is accomplished with comparative ease After the negative cast has been made, the inside is lined with a thin layer of wax and the positive cast is constructed in the manner described below

Construction of Positive Mold

For the construction of the positive cast many materials are available, those most commonly employed being plaster of Paris, gelatin, and beeswax The author prefers "Jaeger's compound," a mixture of beeswax, carnauba wax, and resin

(1) *Plaster of Paris* Of these materials, the simplest and most economical is plaster of Paris To facilitate separation of the positive cast, the inner surface of the negative mold is first lined with a thin layer of a shellac and alcohol mixture (12 grams of brown shellac to 500 cc of denatured alcohol), the liquid being forced into all crevices by stippling with a stiff brush Three successive layers are applied at intervals of 10 minutes When the third layer is thoroughly dry, the inner surface of the mold is brushed with a mixture of kerosene and petrolatum As an alternative to the above procedure soapsuds may be used for the purpose, although considerable detail will be lost The negative mold having been thus treated, a small quantity of thin plaster is poured into it, and the mold is tilted until all surfaces are covered A thicker plaster is then added with a spatula until a thickness of 2 to 3 cm is obtained When the plaster has dried, the negative mold is fractured off with a chisel and mallet

(2) *Beeswax* If "Jaeger's compound" is to be used, the negative mold is filled with boiling water and allowed to stand for 5 to 10 minutes, after which it is emptied and sponged dry While still warm, it is filled with the melted compound and quickly emptied, a thin layer being left on the mold It is then refilled and left undisturbed until a crust 2 to 3 cm thick has formed, at which time the surplus of the melted compound is poured off To give body to the cast, it is packed with a "filler" consisting of paraffin, cornstarch, and flour sweepings The whole is then immersed in a container of cold water, and after 4 to 5 minutes it is removed and the plaster negative fractured off piece by piece with a chisel and mallet, care being taken to avoid damage to the positive cast If it is desired to reproduce the color of the part, the cast is washed with kerosene, dried, and tinted with oil paint mixed with varnish, kerosene, and turpentine

If the part to be cast is of such a shape as to render the removal of a single mold impossible, the negative must be made in two pieces. The simplest procedure is to split the mold while still soft by means of a string or wire. For example, in the construction of an ear cast, the auditory canal is first plugged with cotton, after which a string is attached to the rim of the ear with a little mastisol, the ends being left long. The mold is made in the usual manner, and while it is still soft, traction is made on the string, so that the cast will be split into two parts. When it has hardened, it is removed and its inner surface treated with a separator. The two halves of the cast are then fastened tightly together with a string and the plaster or wax is poured into the interior through a small hole made for the purpose. When the negative is removed, a positive reproduction of the entire ear will remain.

PROSTHESES

A prosthesis is an artificial substitute for a missing part. While it is outside the scope of these pages to discuss the matter in detail, inasmuch as the making of these appliances is an art in itself and is excellently dealt with in standard works devoted to the subject, nevertheless a few of the general principles may be properly mentioned.

Prosthetic appliances are indicated (1) To conceal deformities. The great majority of patients prefer that the missing part be restored from their own tissues rather than by artificial means, inasmuch as a mechanical contrivance, no matter how perfect, fails to furnish the sense of security of a part reconstructed in "flesh and blood." But circumstances are often such that surgical restoration is impossible or impracticable, for instance, in the case of defects too extensive to be surgically repaired, in the aged who are unable to meet the strain of repeated operations, and in patients suffering from malignancies wherein recurrences are anticipated. Here the substitution of the missing part or concealment of the defect by means of a prosthetic appliance is often the only solution of the problem. (2) To aid in the restoration of function—for example, for the correction of defective speech, mastication, and deglutition, as when an inoperable cleft palate is closed with an obturator and velum. (3) To forestall contractions and adhesions of soft tissues and to substitute missing bony framwork in the interval between the loss of a part and its replacement. For example, following a total loss of the central part of the mandible, the surrounding soft tissues contract and draw the fragments out of their normal alinement. A prosthesis attached to the remaining teeth in the fragments will do much to prevent this distortion (p 1269). (4) To hold a skin graft in contact with its bed during vascularization. For instance, in replacing the mucous membrane lining of the nose or mouth, cap-splints are fitted to appropriate teeth, and to these splints is attached an upright carrying a tray to hold the modeling compound. After the impression has been taken, the graft is placed over the mold, applied to its bed, and held in place by locking the upright to the cap-splints on the teeth. (5) To immobilize the bony skeleton—for example, in bone-grafting operations on the mandible.

Generally speaking, the material used for prosthetic appliances should be light in weight, smooth, and easily removable for cleansing purposes. Many substances have been used for the replacement of facial members, and among these are metal, rubber, gutta-percha, papier mâché, porcelain, wax, and gelatin. The latter, however, has largely supplanted all others because of its natural appearance, pliability, simplicity

of construction, ease of fixation, and economy, the patient may be given a mold and taught to pour the member at will. The other materials have many drawbacks Metals are too heavy and do not hold paint, celluloid has a tendency to warp and is inflammable, porcelain requires great skill in modeling, baking, and coloring, and is breakable

Firm retention of the prosthesis is vital to the comfort of the patient Anchorage may be obtained in many ways—i e, by expanding springs introduced into the nasal or auditory canals, by cap-splints affixed to the teeth, by head bands concealed in the hair, and by spectacle frames The surgeon is often called upon to provide an epithelium-lined cavity to support the prosthesis A common example is the lining of a contracted socket for the reception of an artificial eye (p 904)

Construction of Gelatin Prosthesis

For convenience, the general procedure employed in the construction of a gelatin prosthesis is here exemplified in the manufacture of an artificial nose A cast of the face is made in the usual manner (p 1387), and on it the missing member is built out in wax or modeling clay to harmonize with the balance of the face In modeling, the operator is guided by photographs taken of the patient before the loss and by certain rules governing facial proportions discussed under "Analysis of Deformity" (p 643) The built-up nose model is carefully removed and a double cast made of it in plaster, the space enclosed by the mold representing the missing part The mold is cast in metal

A gelatin of a high melting-point is covered with water for a few minutes, shaken free of the liquid, and melted in a double boiler A small amount of glycerin is added to furnish the proper consistency The quantity will vary with the kind of gelatin employed and can be arrived at only by trial and error Coloring matter is added in such proportions as to match the patient's skin The melted liquid is poured into the previously prepared mold through a small hole made in it for the purpose When the material has solidified, it is separated from the mold and attached to the face with mastisol Cosmetics may be applied to enhance the illusion

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